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SOUTH AUSTRALIANS

AND THEIR

ENVIRONMENT

UNIVERSITY OF TORONTO
DEPARTMENT GEOGRAPHY

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BY

A. GRENFELL PRICE, M.A.

DIPLOMA IN EDUCATION, OXON. AUTHOR OF "A CAUSAL GEOGRAPHY OF THE WORLD"

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With the author's compliments

Mr. A. G. Price.

~~Magdalen College~~ St. Peter's College
Oxford. Adelaide

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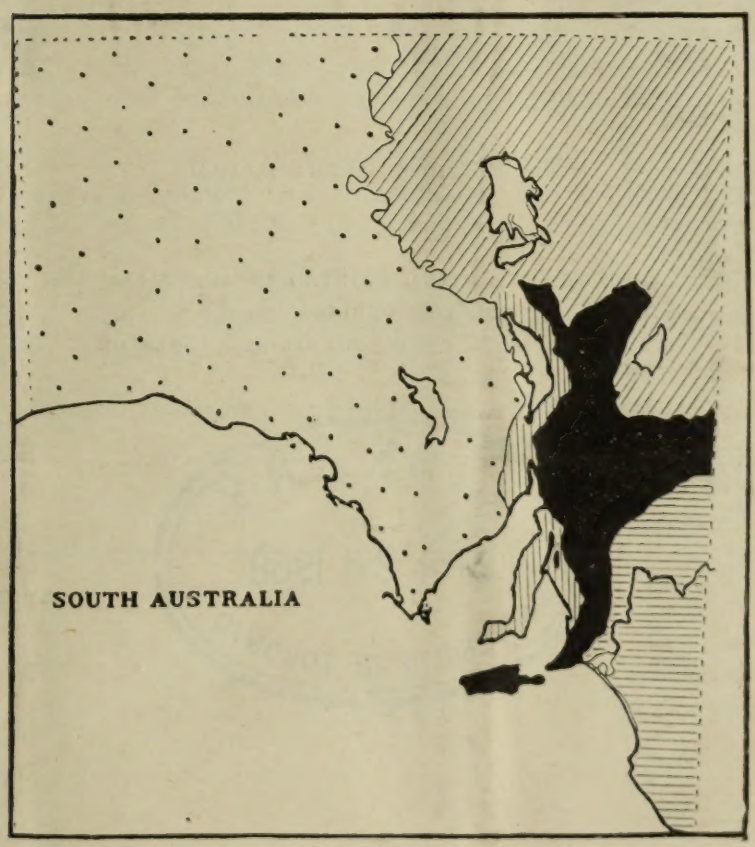

South Australia.—Main Geographical Divisions.

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PREFACE.

THE following short work has been written to meet the need of an introduction to the human geography of South Australia. In so small a space it has been impossible to treat the subject exhaustively, but it is hoped that the outline presented may arouse interest and indicate some paths along which anthropogeographical study can be profitably carried out. If cost of publishing decreases, an opportunity may occur to add a complete historical section and more detailed locality maps.

The writer is under considerable obligation for generous help from several sources, but wishes to acknowledge particularly suggestions given by Dr. Charles Fenner, F.G.S., who also kindly contributed Figs. 7 and 12.

Use has been made of publications by Professor Griffith Taylor, Mr. L. Keith Ward, Government Geologist, and Mr. W. L. Johnston, Government Statist, to whom the writer is indebted.

Other acknowledgments will be found in the text.

A. GRENFELL PRICE.

St. Peter's College,
November, 1921.

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INTRODUCTION

SOUTH AUSTRALIANS AND THEIR SURROUNDINGS

The geography of South Australia, like that of all other inhabited areas, illustrates a reciprocal action between the human race and its environment or surroundings. "Man is a product of the earth's surface. The earth has mothered him, fed him, set him tasks, directed his thoughts—entered into his bone and tissue, into his mind and soul." Broadly speaking, this influence is carried on silently and persistently by three main types of surroundings—physiographic, biological, and social. The first of these includes the various actions of physical environment, such as climate, land and water surface, minerals, etc.; the second the influence of all kinds of animal, vegetable, insect, and microbe life; the third the effect of race, of government, and of mode of living under which every individual is born and nourished.

These factors, which together comprise what is known as geographical control, place an indelible stamp upon man, and influence every phase of his development. It must not be thought, however, that the human races are solely the product of these forces, and are driven by them to an irrevocable destiny. On every side humanity is seen turning upon their environment and, within certain limits, subduing nature to their will. Thus, if man cannot control climate, he can at least increase its natural advantages or mitigate its faults. If he cannot make vast alterations in the land and water surface, he can go far in moving mountains and creating lakes and rivers. On animal, vegetable, and insect life he exerts vast influence by germinating, transplanting, and destroying. In social and political matters he changes his mode of life and government with his needs and desires. In this control of nature, modern civilization has given man scientific weapons of amazing strength and keenness; it has been estimated that the steam engine alone has added to his power the force of a thousand million men.

The development of the Anglo-Saxon race in South Australia forms an interesting example of the interrelation between man and his environment. Here can be seen not only the usual reciprocal control of man and nature, but their interplay in a new and virgin land, which is already placing its stamp upon the immigrants. Unfortunately, little scientific work has been done on this last subject, but we can indicate some probabilities, from obvious changes, from scientific data published in regard to Australia as a whole, and from scientific work done on incoming races in America. Thus, though British people have been in South Australia for less than a hundred years, it can be suggested that their speech is already altering in type and vocabulary from that of the land of their origin. Language is to a large extent "fixed" by the use of English literature, but it is already evident that accent is changing, and new words are being introduced to suit new or local conditions. Similarly, in regard to physique, it seems possible from measurements of cadets, that, as in America, the change of environment is creating differences between the parent stock and its overseas descendants. Census figures, again, show that geographical control is affecting the length of life. Contrary to a popular belief that the present generation will not live as long as its forefathers, figures indicate that over the last few years the expectation of life has, on an average, increased eight years for both men and women in Australia. Perhaps it may even be hinted that the enormous growth of thrift, as shown by the increase in Savings Bank deposits and life assurance in South Australia, may at

any rate be partly due to a growing consciousness of the variability of climate, and probability of periodic droughts. These are, however, merely suggestions, for changes in national character and life can be studied only by scientific methods based on the widest data.

In the ordinary facts of life and industry in South Australia, the relation between man and his surroundings, and the changes effected by a new environment, are far more clearly marked. The British came to the country with ideas and activities created in a land where climate was cool temperate insular, and industries, largely owing to the presence of coal and iron, were mainly manufacturing in type. On their arrival they found that they had by necessity to adjust themselves to a land where climate was warm temperate continental, and whose main industries could at first, at any rate, be agriculture, pasturing and mining only. Comparing South Australia, after eighty years of settlement, with Great Britain, there can be seen on every hand changes in such things as mode of life, industry, architecture, clothes, and recreation. Thus, for example, non-British industries have been established (e.g., orange growing), and British ones neglected (e.g., cotton spinning) or greatly altered in the face of local conditions (e.g., wheat and wool growing). In the same way houses have been largely adjusted to provide comfort in times of heat instead of cold, and white or thin clothes worn for similar reasons. In recreation there can be seen in Australian football the evolution of a game suited to fairly dry winter conditions in a land where economy of space is unnecessary. Similarly, national development in cricket and tennis may possibly be attributed to a climate which renders these games suitable for so much of the year.

Even in the 380,000 square miles of South Australia, where there are no vast climatic or topographic variations, such changes as exist create differences in the life and industry of the people. Thus the man on the land leads a very dissimilar life to the city dweller, and has often very different ideas, while within the country regions or city districts themselves considerable differences appear. Thus within a comparatively small area, Mount Lofty and its vicinity, can be contrasted variations in geographical control on the lives and industry of market gardeners in the peaty valleys of the highlands with some 30 inches to 40 inches of rainfall, vignerons of the sunny western slopes with some 25 inches, and wheat growers of the neighbouring alluvial plains, where the fall is from 15 inches to 20 inches. Similarly, the so-called Murray basin exhibits striking contrasts between the agricultural and dairying industries of the rich volcanic lands in the moist Mount Gambier area, the wheat culture of the sandy mallee country where rainfall is just sufficient for this purpose, and the prosperous fruit industries of the irrigation settlements in the arid valley of the river.* Even city life varies between town and town and in each individual city. Thus smelting and mineral export centres, such as Wallaroo and Port Pirie, exhibit very different examples of geographical control from wheat ports like Port Lincoln or agricultural centres like Gawler. In Adelaide, again, life and industry show enormous

*Mount Gambier is a particularly good example of geographical control. Dr. Fenner has shown that "but for the existence of the volcano the site of the thriving town of Mount Gambier would doubtless consist of a broad limestone plain, sparsely settled, and economically unimportant." Life in the agricultural and pastoral areas mentioned above can be contrasted with that in regions, often of an arid or semi-arid character, where the control is primarily of a geological nature, i.e., the presence of minerals. Such desert mineral zones are found at Iron Knob and the Stuart range opal fields, while of a somewhat similar type is the Broken Hill silver-lead-zinc area, which, although in New South Wales, has greatly influenced the development of South Australia through the geographical necessity of shipping the ore from Port Pirie. In the more fertile regions of the State, mineral control can be seen in the copper mines and salt industry of Yorke peninsula.

If "Desert" may be used for Iron Knob (rainfall 10")

contrasts; for example, between the manufacturing and seaside districts, or between the city and suburbs.

All these variations in South Australia illustrate the interrelation of man and nature. Geographical control makes certain modes of life and industry possible, and, within limits, the people of the state adjust themselves to natural laws, and improve and alter their surroundings even where they cannot completely control them. Thus South Australians temper even the effects of climate, the most unalterable factor of the physiographical environment, by means of water conservation, irrigation, and the sinking of wells and artesian bores. Indeed, recent research in the Victorian mallee areas tends to indicate that rainfall itself can be improved by the clearing of land and cultivation of wheat.* Similar control to that over climate is exercised by man on the topography in such cases as quarries, railways, and roads; the water surface in the same way is altered by draining and dredging. On the biological side the aborigines and animals are following the tragic law of the disappearance of lower in the face of higher types. Native flora, more particularly the forests, appeared likely to follow in the same direction, till South Australians at last realized the folly of destroying valuable species adapted by long experience to climatic conditions.† The interrelation between man and the insect and microbe world is less clearly understood, but it is realized that in these realms the people of the State have both good allies and bitter enemies. Scientific effort to strengthen the former and destroy the latter, which comprise some of the worst pests and are responsible for the most serious diseases, is becoming an increasingly important factor in national life.

How great have been the efforts and achievements of the founders of the state stands out in every page of this little book. They faced the difficulties of changed environment with fearless hearts and ceaseless energy, and they created for their children a priceless heritage to make or mar. The human race attains its greatest development in those lands where nature yields her treasures neither too easily nor too grudgingly, where success comes to those alone who "strive and hold cheap the strain." South Australians have been of this type in the past, and their land has given them freely of her best. The future lies in the hands of present generations.

Three thousand years ago, on the shores of the Ægean, a Mediterranean land, not unlike our own, gave to the world the most glorious art, language, and literature mankind has ever seen. A thousand years later, another Mediterranean people prepared the mighty gifts of law and organization. From these lands European civilization spread westward to give birth to modern science, and to those great ocean peoples of which the British are members. Under the influence of a climate such as helped to make Greece and Rome the glory of the past, and with the blood of British Imperialism in their veins, it is for South Australians to see that their land does not fail to contribute something not unworthy to the great tide of human progress.

*It is interesting to note in this connection that phenomena, which are in general looked on as evils, are frequently of service to mankind. Hence droughts are beginning to be regarded, in the light of modern scientific knowledge, as nature's periods of rest, and certainly the wonderful recovery of the state after such times of depression as that of 1914 (Fig. 14) seems to show that in regard to wheat at least there is much in the theory. Similarly, the high evaporation, which is partly responsible for the aridity of large areas, is utilized for the most important salt industry in Australia (Chapter I).

†Certain particularly well-equipped alien types of plants, birds, animals, etc., have thrived so greatly in the new environment that they threaten the existence both of native forms of life and of other exotics introduced by man for his needs. The damage wrought by foxes, rabbits, starlings, prickly pear, blackberries, etc., together with many other aliens, are examples of this.

NORTHERN TERRITORY
QUEENSLAND
WEST AUSTRALIA
SOUTH WALES
TOMKINSON RANGES
MANN RANGES
MUSGRAVE RANGES
BIRDSVILLE TRACK
EVERARD RANGE
Charlotte Waters
Birdsville
Hamilton Creek
Alberga River
Marumba River
Oodnadatta
Algebuckina
Hergott Sp.
Farina
Hawker
Quorn
Port Augusta
Port Pirie
Port Lincoln
Streaky Bay
Ceduna
Eucla
Forrest
Kalgoorlie
Esperance
Albany
Perth
Geraldton
Carnarvon
Onslow
Roebourne
Port Hedland
Broome
Derby
Wyndham
Darwin
Tennant Creek
Alice Springs
Oodnadatta
Birdsville
Charlotte Waters
Farina
Hergott Sp.
Quorn
Hawker
Port Augusta
Port Pirie
Port Lincoln
Streaky Bay
Ceduna
Eucla
Forrest
Kalgoorlie
Esperance
Albany
Perth
Geraldton
Carnarvon
Onslow
Roebourne
Port Hedland
Broome
Derby
Wyndham
Darwin
Tennant Creek
Alice Springs
NULLARBOR PLAIN
LAKE EYRE
LAKE TORRENS
LAKE GAIRDNER
LAKE FROME
TIRARI PLAIN
STUART'S STONY DESERTS
STUART'S RANGE
Stevenson Creek
Hamilton Creek
Alberga River
Marumba River
Algebuckina
Hergott Sp.
Farina
Quorn
Hawker
Port Augusta
Port Pirie
Port Lincoln
Streaky Bay
Ceduna
Eucla
Forrest
Kalgoorlie
Esperance
Albany
Perth
Geraldton
Carnarvon
Onslow
Roebourne
Port Hedland
Broome
Derby
Wyndham
Darwin
Tennant Creek
Alice Springs

SOUTH AUSTRALIA
SHOWING
Land above 2,000 feet
" between 2,000 feet & 1000 feet
" " 1,000 " " 500 "
" " 500 " " Sea Level
" below Sea Level
Principal Reservoirs
Railways
Broad Gauge
Narrow Gauge
Standard Gauge
SCALE
MILES
From the map by L. Keith Ward, Government Geologist
GREAT AUSTRALIAN BIGHT
FLINDERS RANGES
EYRE'S PENINSULA
SPENCER GULF
YORKE PENINSULA
GULF ST VINCENT
INVESTIGATOR ST
KANGAROO I.
LAKE TORRENS
LAKE EYRE
LAKE GREGORY
LAKE CALLABONNA
LAKE FROME
LAKE BLANCHE
LAKE CALLABONNA
LAKE VICTORIA
LAKE ALEXANDRINA
LAKE ALBERT
LAKE BONNEY
MURRAY RIVER
VICTORIA
NEW
Thevenard
Streaky B
Minnipa R.S
Iron Knob
Whyalla
Port Pirie
Port Augusta
Quorn
Carrieton
Orroroo
Yunta
Cockburn
Glary
Hawker
Peterborough
Jamestown
Georgetown
Gladstone
Narridy
Booleroo Centre
Wirrabara
Beetaloo
Port Broughton
Bute
Snowtown
Clare
Kooringa
Morgan
Waikerie
Renmark
Loxton
Paringa
Moorook
Blanchetown
Eudunda
Kapunda
Angaston
Nuriootpa
Tanunda
Marrabel
Mt Pleasant
Gawler
Hamley Bridge
Balaklava
Maitland
Minlaton
Yorketown
Edithburgh
Adelaide
Glenelg
Brighton
Hallett Cove
Noarlunga
Willunga
Victor Harbor
Goolwa
Murray Bridge
Narcoonda
Meribah R.S
Peebinga
Pinnaroo
Lameroo
Tailem Bend
Murrayville
Tintinara
Border Town
Wolseley
Kingston
Naracoorte
Penola
Robe
Beachport
Millicent
Mount Gambier
Port MacDonnell
Port Lincoln
Boston B
Cummins
Elliston
Flinders I.
Venus B
Anxious B
Streaky B
Thevenard
Ceduna
Fowlers B
Coffins B
Hall's Bay
Denial B
Nuyts Arch
Encounter B
Rivoli B
Lacepede B
Guichen B
Discovery B
Rivoli B
Port Macdonnell
Portland
Cape Nelson
Cape Bridgewater
Cape Duquesne
Cape Otway
Cape Northumberland
Cape Jaffa
Cape Martin
Cape Willoughby
Cape Jervis
Cape Spencer
Cape Borda
Cape Torrens
Cape Gantheaume
Cape Du Couedic
Cape Bouguer
Cape Bouguer
Cape Bouguer

CHAPTER I.

THE GREAT VALLEY OF SOUTH AUSTRALIA.

As South Australia embraces a considerable area (380,000 square miles) there are naturally physical variations by means of which it can be subdivided. In regard to surface, five main geographical areas can be distinguished: the Great Valley, Central Highlands, Murray Basin, Western Coast and Plateau, and Lake Eyre Basin. (See cover diagram.)

Most of these regions can be further divided. In relation to population, by far the most important area of the state is the Great Valley, which contains the greater portion of the people, the chief industrial and commercial centres, and the main economic harbours.

1. Physiography of the Valley.

This geographical area consists of a long belt of shallow water and low-lying land between the central highlands and western plateau edge. The chief minor areas it contains are Spencer and St. Vincent gulfs, the eastern coastal plains, Yorke peninsula—an important ridge between the sunk land forming the two gulfs—and a narrow valley connecting the gulf areas to the heart of the continent, viâ Lake Torrens. From the economic point of view, the last is more satisfactorily considered with the Lake Eyre basin. The western side of the region forms part of Eyre peninsula. On the south the boundary is a great ocean depression off Kangaroo Island, known as Jeffrey's Deep, and on the north a low divide of ancient rocks—the Willouran and Babbage line—between Lakes Eyre and Torrens. (Fig. 1.)

The gulfs are comparatively shallow depressions running into the interior for about one hundred and two hundred miles respectively. They have some moderating effect on climate, but, although they help to push the isohyets—lines joining places of equal rainfall—to the north (Fig. 4), their influence in this respect is not to be compared with that of the central highlands. As the gateway of the state, however, they are of immense economic and commercial importance. The eastern coastal plains are the most valuable portion of the valley. They form a practically continuous line from the vicinity of Adelaide to Port Augusta at the northern end of Spencer gulf. The greatest width attained is just north of the head of St. Vincent gulf, where the plains are forty miles in width. The chief local divisions are the Adelaide and Port Wakefield plains to the east of St. Vincent gulf, and the Port Broughton and Port Pirie plains to the east of Spencer gulf. Most of these areas have been formed below the sea floor and subsequently elevated. Much of the region is however covered with fertile alluvium brought down from the highlands by numerous streams and torrents.

Yorke peninsula is also a low-lying region. It is about a hundred miles long and from thirty to forty miles in breadth. Its foundation is of ancient rocks, and in the north these contain the greatest copper deposits of the state. Much of the area is limestone and mallee country, but it is of great economic value on the whole. The narrow valley from the head of Spencer gulf to the Willouran line is of little importance. (Section 2.)

The great valley is frequently called a rift or fault valley from the manner of its formation, a sinking of the land in comparatively recent times. (Chapter II.) Much of the area has been formed below sea-level and the sea at one time probably extended eastward to the base of the Mount Lofty and other foothills. Subsequent elevations have produced the present form of the valley, but, although these have resulted in fertile

plains, it will be seen (Section 3) that these movements have put serious handicaps on sea trade.

2. The Valley the Gateway of the State.

The great valley of South Australia is of immense importance to the state. The gulfs comprise the only great openings in the southern Australian coast, and, with the exception perhaps of Port Philip, are the most important economic gateway in the south of the continent.

This fact is not only evident in the distribution of the population, industry, and trade to-day, but has been a prominent feature in the whole exploration and settlement of the state. The first explorers to navigate the gulfs were Flinders (British), in the "Investigator" (note Investigator Strait), and Baudin (French). These sailors entered the gulfs from the west and east respectively, in 1802. Flinders slightly preceded Baudin, and named most of the gulf area, including Mount Lofty. He realized at once the importance of a great sea gateway running far into the continent, but sought in vain for a river debouching into the gulfs and providing a waterway into the interior. When South Australia was founded in 1837 the site of Adelaide was chosen partly for its command of the gulfs and supposed inland waterway. Early in the history of the young state attempts were made to find the supposed route to the interior, until in 1840 the great explorer Eyre saw near Mounts Deception and Hopeless that the valley at the head of Spencer gulf contained no mighty river, but an arid waste studded with salt swamps. Notwithstanding this disappointment, South Australia has continually looked northwards. The state has endeavoured to develop the interior, to control the Northern Territory, and to push a railway northwards across Australia, efforts which have perhaps distracted attention from more fertile areas. Although the northern regions are now largely settled by pastoralists, and two of the greatest railways of Australia penetrate the interior from the head of Spencer gulf, the fact that the great valley is still the gateway of the state is primarily due to the fertility and mineral deposits of the plains and highlands, of which it is the immediate outlet.

3. Coastline of the Valley.

The coast line of the great valley is not only a gateway, but also a barrier to the development of the inland areas of the state. It possesses all the disadvantages of recently elevated shore lines, but the rich hinterland and converging communications have fully justified the formation of expensive artificial harbours. As is usual in coasts of recent elevation—(there has been a very late uplift of about 12 feet and the land is still rising)—the shore is for the most part low-lying and swampy, with only a few small shallow estuaries, which offer little natural shelter to shipping. Such a shore line represents a strong contrast to recently sunk areas, where the drowned valleys form deep, safe harbours—e.g., Sydney. The history of the early settlement of the state forms an interesting illustration of these points. The first anchorage off the mainland, Holdfast Bay, was very exposed, and, on its discovery, the Port Adelaide river was used to shelter the small vessels of the colonists. Here were all the disadvantages of an elevated tidal estuary. The old port was higher up the river than the present dredged anchorage; vessels lay on the bottom at low tide, and passengers and goods were dumped ashore in mud and mangroves. As the colony extended, proper wharves were built in deeper water lower down the river, which was also dredged to keep pace with the growing size of vessels. Later on, when the capital area attracted practically the whole trade of the state, and the size of vessels increased enormously, it was found necessary to build a more

accessible "Outer Harbour" on the seaward, instead of the inland edge, of the coastal strip. Port Adelaide and its outer harbour are now repeating on a small scale the usual struggle which is waged between outer and inner ports, such as Rouen and Havre, Bremen and Bremerhaven, Seville and Cadiz.

The other harbours of the great valley demonstrate similar difficulties in finding good seaports on a recently elevated shore line. Some, like Ports Pirie and Augusta are dredged inlets only accessible to large vessels at high tides. Others—e.g., Wallaroo and Port Victoria—suffer from exposure. None but Port Lincoln—itself really a western plateau port—has any qualification for a good harbour, except the richness of the hinterland. It has been primarily this last quality which has given Port Adelaide and the Outer Harbour four-fifths of the state's oversea trade, and Port Pirie and Wallaroo the handling of the whole of the mineral wealth of Broken Hill and Wallaroo and Moonta. Owing to rich economic products in the hinterland many smaller ports are also of very considerable value, in spite of the disadvantages of exposure or shallow estuaries; for example, Port Wakefield, Ardrossan, and Edithburg, in St. Vincent; Port Victoria, Port Broughton, and Port Augusta, in Spencer gulf.

4. The Climate of the Valley.

Climate—the average condition of the weather, together with variations from the average both in frequency and amount—is the most important of the various geographical controls which influence man and his industries. Any large region of the earth's surface contains areas which are inhabitable if climatic conditions are in any way suitable, but very large regions are totally unfit for mankind if the climate is unfavourable (e.g., hot and cold deserts). Though this is not as evident in South Australia as in the Antarctic or Sahara deserts, the contrast between the well-watered coastal districts and the arid central and western zones illustrates the extraordinary importance of climatic control on human life and industry.

Generally speaking, the climate of the valley is typical of that of the state as a whole, with the possible exception of a small area in the north east. A consideration of life and industry shows its main characteristics. Thus, from orange growing or viticulture it appears that it is warm, from the possibility of outdoor life at all times and seasons, temperate, and by the considerable climatic variations between winter and summer, tending towards extreme or continental. The climate is thus warm temperate continental, a type usually known as Mediterranean by its prevalence in that region of the world.

This kind of climate is marked by long dry summers and mild moist winters, most of the rainfall being in the latter season of the year. It is very suitable for white races, who, as will be seen later, can engage in varied industries, resulting in cool temperate products in the colder, and subtropical products in the warmer regions. (Compare the oats and barley of Kangaroo Island with the Mediterranean fruits of the Adelaide plains.)

As in all climates, the principal elements are temperature, wind, and moisture. Temperature in this part of the state is high, but by no means unbearable, though December, January, and February approach scorching. (See Appendix, Fig. 15.) The winter months, June, July, and August, have that type of climate which is, on the whole, most favourable to the white races. The average range between the hottest and coldest months is moderate in Adelaide, 21° F. (January, 73° F.—June, 52° F.) Higher up the valley the mean range rises rapidly, though the gulfs provide some moderating influence. (Fig. 2.) Mean daily range, like mean monthly

range, similarly increases inland, but compensation is usually given by the fact that greater day heat is frequently offset by cooler nights. (Chapter V.) Variations, both in monthly and daily range, are most necessary to

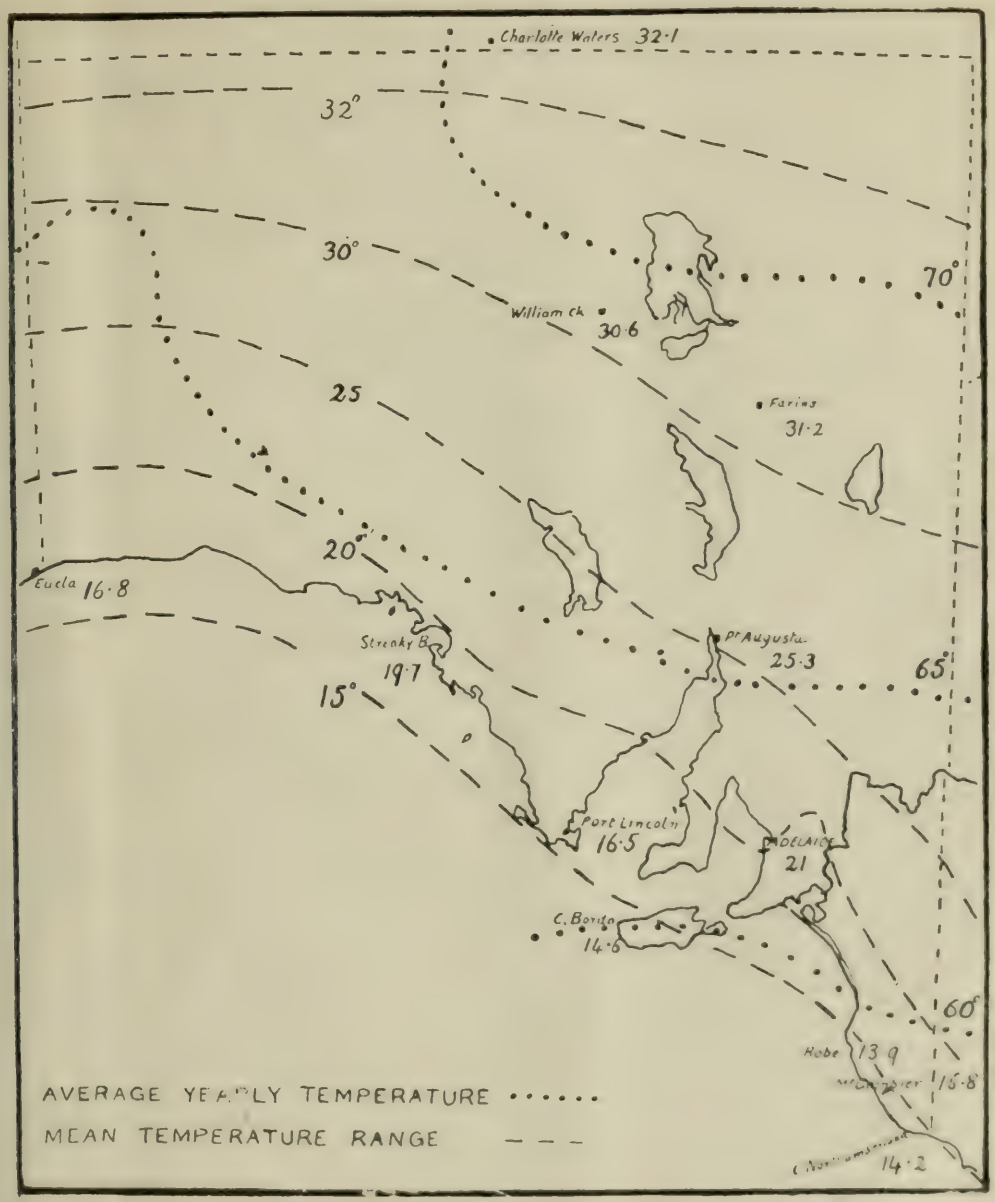


Fig. II. Annual Average Temperature and Mean Temperature Range. (Adapted from Professor Griffith Taylor: The Australian Environment.)

man in warm countries, and it is the frequent and severe changes in temperature that help to make South Australia so healthy. Extreme annual range of temperature and the frequency and duration of heat spells also affect human beings considerably. The highest shade temperature recorded at Adelaide is 116° F. (1858), the lowest 32° F. (1908). This range of 84° F. of temperature is high, but it is greatly exceeded in parts of Siberia (171° F.) and North America (153° F.).

From the Adelaide records, heat spells do not seem to be altering in number or duration. On an average the thermometer stands above 90° F. for three successive days about seven times a year. Many of the effects of temperature on life and industry appear in the sections following. Fig. 3, however, is interesting in indicating its possible direct effect upon the death-rate. It will be noticed that this rate is highest above the mean in January and August. It can be seen, however, that extreme summer heat probably produces a greater effect than winter cold.

Winds, the second element of climate, are important to the inhabitants of the great valley in their effect on temperature, and because they are the great water bringers of the state. They are broadly of three classes, permanent, periodical, and occasional such as cyclonic disturbances. The permanent winds bring the valley its primary, and

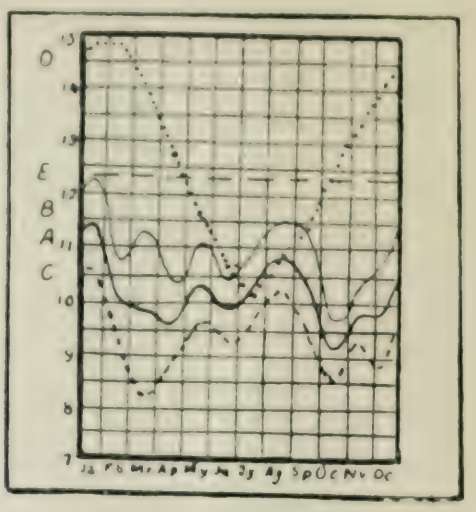


Fig. III. Sou h Australian Monthly Death Rate and Mean Monthly Temperatures (Adelaide). Death Rate per 1,000 persons: A. General. B. Male. C. Female. D. Mean Monthly Temperatures (1 square 5°). E. Average Annual Temperature (63°). (Based on Commonwealth Year Book.)

the periodical winds its secondary rainfall, while the occasional winds have considerable local influence. These winds require some explanation. Air flows from regions of high to those of low pressure, where an updraught has been created by higher temperatures. This accounts for the great interchange of atmosphere between the equatorial and polar regions, as some air currents rise and flow polewards from the hot equatorial lands, while others move equatorwards to take their place. The latter winds, the south east trades in the Southern Hemisphere, are on the surface of the earth between latitude 0° and 30° south. The winds moving polewards (north west anti-trades) are not found on the surface until latitudes 30° to 60° south, where they have been changed by the earth's rotation into westerlies (Brave west winds) or even south westerlies. These two systems mainly occupy tropical and Antarctic low pressure zones, and, as South Australia is on the high pressure region along the tropic of Capricorn between them, the winds must largely be water drinkers moving north or south away from the state. This is indeed the case. The dominant winter winds are northerlies, moving to the southern low pressure area; the dominant summer winds, southerlies, moving north to the tropical low pressure zone. Fortunately, however, all wind and pressure systems move north and south with the sun on his march between the tropics. Hence in the winter the southern low has advanced far enough northward to bring the great valley frequently under the influence of the permanent westerly winds, which sweep along the southern coast and provide the primary or winter rainfall. In summer, on the other hand, this belt is well down in the Antarctic, but the tropical low has come far enough south with the sun for the south east trades to be found in the north of the state. Unfortunately, these permanent winds

are dry water drinkers of little economic value. The northerly low is, however, responsible for periodic winds which produce the secondary or summer rainfall of the great valley. These are monsoonal winds, drawn in from the north west by the great heat of the continent, and sometimes extending to the southern areas. These currents have traversed large arid regions before reaching the great valley, but at times bring good rains. A minor type of periodic winds are sea and land breezes caused by the relative coolness and warmth of the sea and land by day and night. These winds, particularly the cool sea breeze in the daytime, are partly responsible for the growth of seaside resorts, such as Glenelg and Henley Beach.

(The variability of the great valley climate, mentioned above, is largely due to great wind eddies, built up on the edges of the south temperate zone, and carried along in the main wind systems. These eddies consist of two types, anti-cyclones, or areas of high pressure, with outflowing winds on the earth's surface, and cyclones, or low pressure

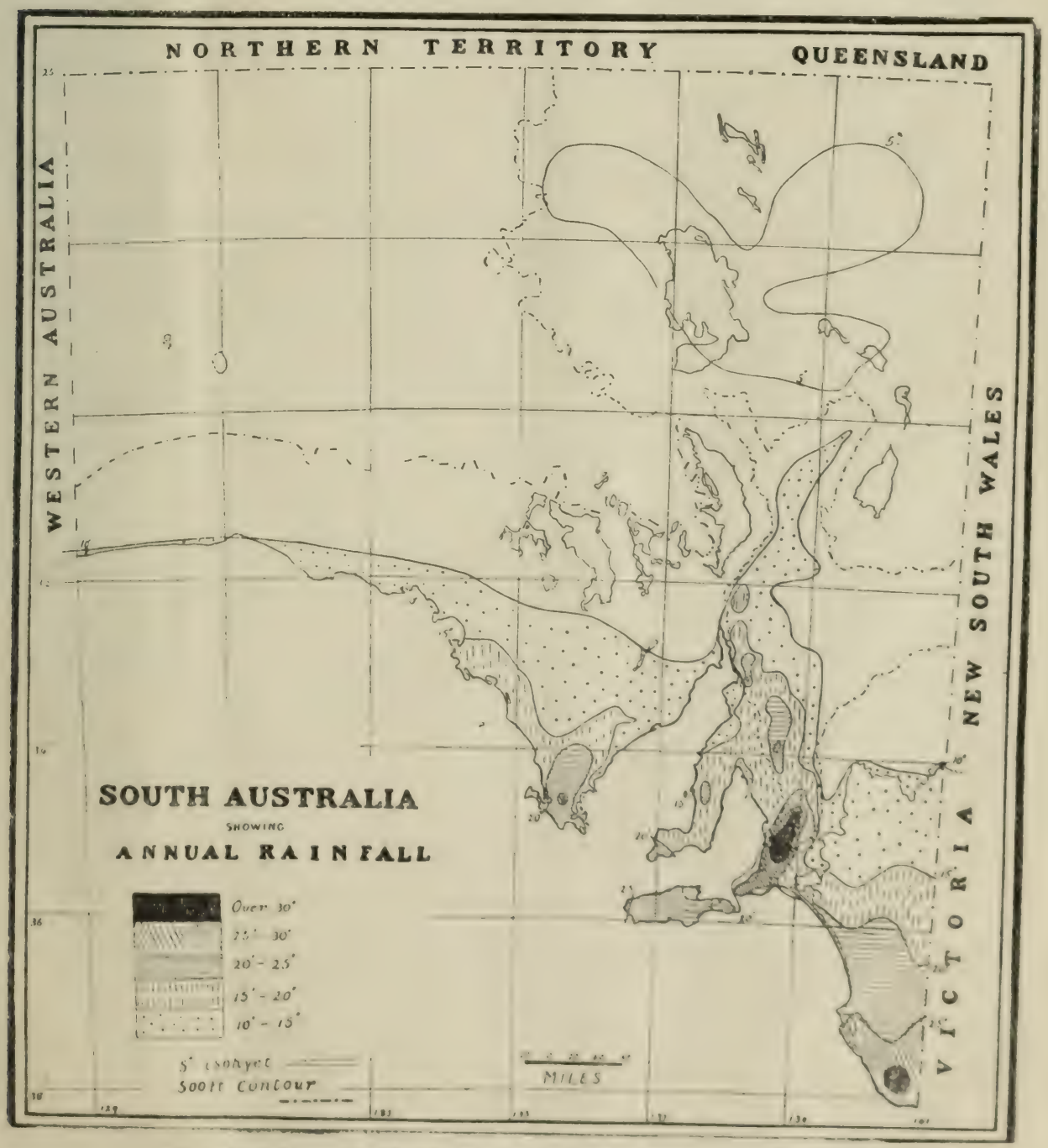


Fig. IV. (From the Map by L. Keith Ward, Government Geologist.)

areas, with inflowing surface winds. The movements of these highs and lows are far from thoroughly understood. The lows are of two types, tropical and Antarctic. The tropical lows move spirally from north west to south east, and merge with the Antarctic lows to the east of the state. The paths of the Antarctic lows usually lie over the ocean. The highs, which are the most common atmospheric conditions, pass across the state from west to east, in number about four to seven a month, and at the rate of about 500 miles a day. They are frequently larger than Australia in area, and are accompanied in front by cool conditions, and in the rear by rising temperature and north winds. The southerly lows are usually smaller and of greater velocity; they are accompanied in front by north winds and warm conditions, and in the rear by cool southerlies. A full description of these phenomena will be found in Professor Taylor's "Australian Meterology," 1920.)

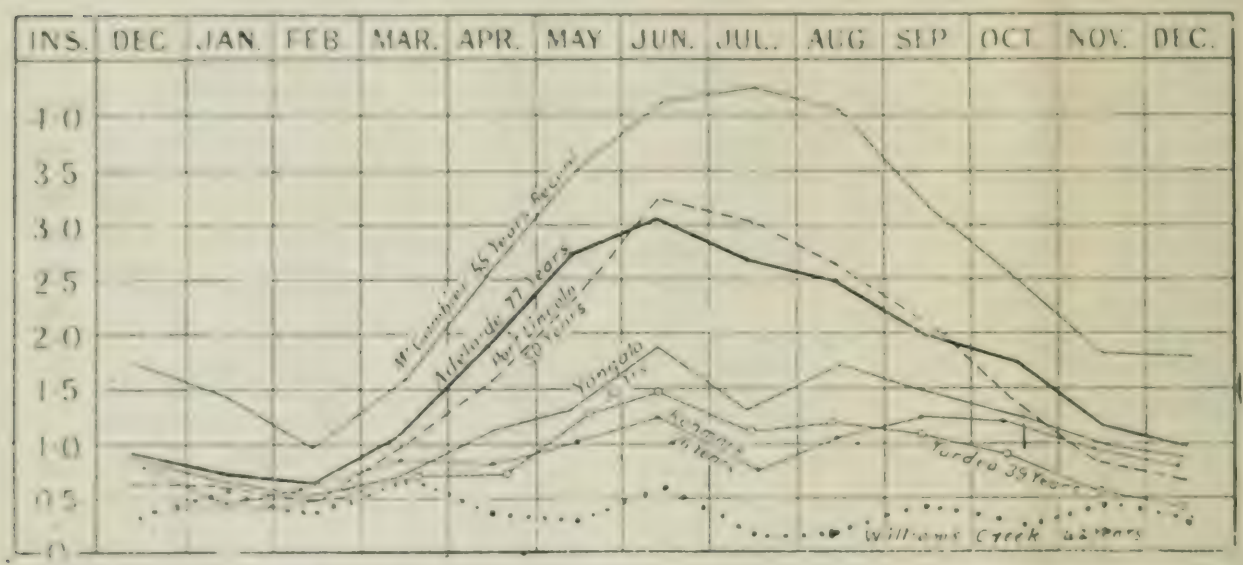


Fig. V. Monthly Rainfall in inches. (From Professor Griffith Taylor: The Australian Environment.)

Rainfall is by far the most important climatic element in the great valley, or in any other region of the state. As has been explained above in discussing winds, the greater portion of South Australia receives a primary winter rainfall from the Antarctic ocean on the south, and a secondary summer rainfall from the Indian ocean on the north. In the case of the great valley it is the distribution of the former rainfall in time and amount that largely accounts for the existence and variation of the agricultural and pastoral industries of the area. Fig. 4—Annual Rainfall—illustrates the precipitation in the great valley. It will be seen that the heaviest fall, 20 inches–25 inches, occurs on the south eastern margin of the plains, and on the southern portion of Yorke peninsula. Further up the valley, as distance from the ocean increases, the fall declines to 15 inches to 20 inches, until in the upper portions of the two gulfs, 10 inches to 15 inches only are recorded. As long as the effect of the gulfs is maintained the rainfall exceeds 10 inches, but the 10 inch isohyet touches Port Augusta, and to the head of the valley less than 10 inches are found. The map thus presents a striking example of a transition from oceanic to continental conditions of rainfall. The only evidences of the effect of altitude in the valley area are on the rising slopes of the eastern plains, and around Maitland on Yorke peninsula, where there is a slight increase in elevation and rainfall.

The effect of altitude will however be seen more fully in Chapter II.

It is obvious from this distribution, and its rapid diminution towards

the north, that the rainfall is almost entirely of the winter type. This is fully borne out by Fig. 5, which shows that practically the whole of the Adelaide fall of 21 inches occurs between April and November. Thus the three wettest months, May, June, and July, total 8½ inches on an average; the three driest, December, January, and February, under 2½ inches. Again, June, the wettest month, has over 3 inches; February, the driest, little more than ½ inch. Even at Port Augusta, nearly 200 miles nearer the tropical low pressure belt, February is still the driest month, with a rainfall less than half that of June, which is still the wettest month.*

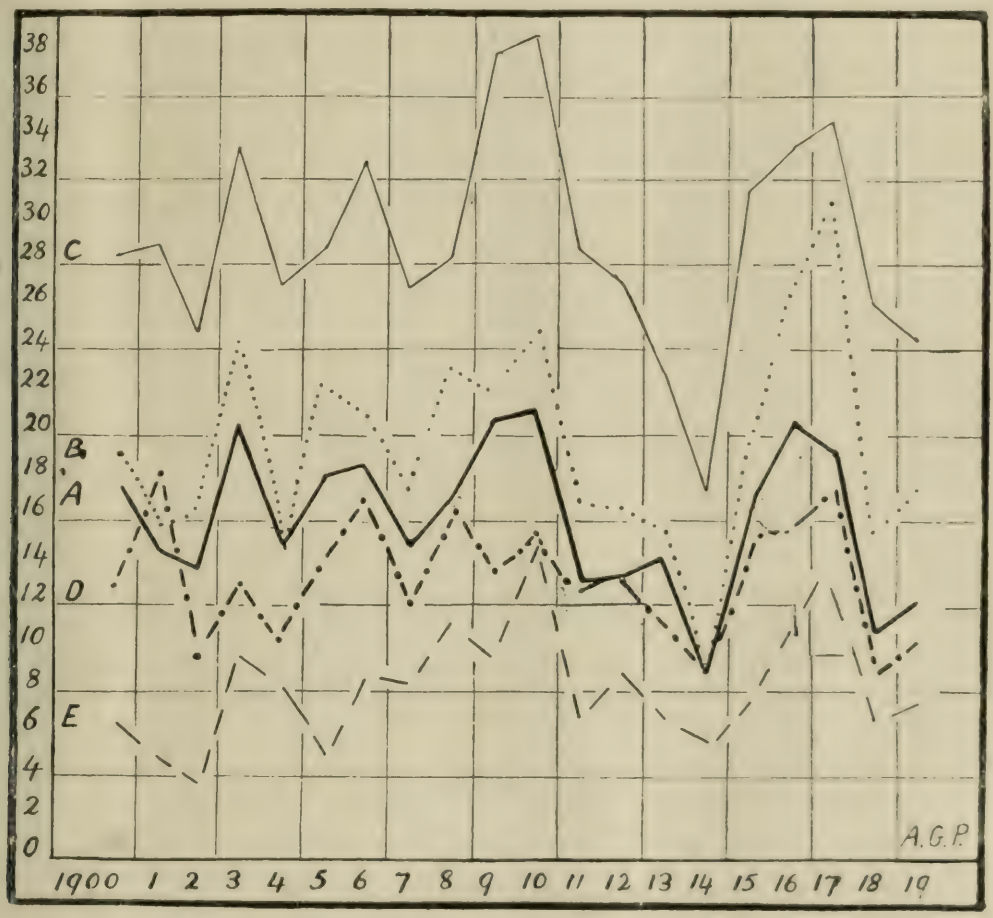


Fig. VI. Annual Rainfall, 1900-1919: A. County Gawler, Great Valley. B. County Stanley, Clare Area Central Highlands. C. County Grey, Mt. Gambier District, Murray Basin. D. County Jervois, Cowell Area, Western Plateau. E. County Manchester, Port Augusta Area, Great Valley and Western Plateau. (Compiled from data supplied by the Commonwealth Meteorologist to the South Australian Statistical Register.)

The importance of this rainfall will be discussed in many aspects under population and industry, where its effects are obvious in every phase of life. To take full advantage of its benefits and mitigate its faults has been the main problem in the settlement of the state.

Note. Four important causes of South Australian rainfall may be noted here:

(1) The movement of moist air from warm to cool latitudes or zones, as when a tropical low extends southwards.

(2) By falling barometric pressure, as when an Antarctic low sweeps the edge of the continent.

*This rainfall is not very variable. Professor Gregory has shown that the annual rainfall of Adelaide keeps far closer to the average than that of Sydney, and that the distribution is more uniform over the whole of South Australia than over other states. Fig. 6 shows the variations for the last twenty years in certain counties, two of which, Gawler and Manchester, are partly situated in the great valley. It will be seen that the Gawler region has averaged from 8.6 inches to 21.2 inches over the period, while Manchester (the Port Augusta area) has received from 3.9 inches to 15 inches.

(3) By rising barometric pressure when the low centre has passed the rainfall area and an advancing high causes a crowding of the isobars.

(4) By the forcing of moist air currents from sea level to higher and cooler strata, by the sea coast or highlands. (Chapter II. Section 3.)

Professor Taylor points out that the first of these causes, and one of the most important, has been little discussed. In South Australia it is a chief reason for the breaking of dry spells (e.g., in 1913).

5. Communication in the Valley.

The main types of communication in the great valley are water, railways, and roads, all of which illustrate, both by history and distribution of settlement, the comparative ease of transport in lowland areas, particularly where land traffic can be supplemented by water routes. In regard to water traffic, the gulfs present an easy and reasonably safe avenue for transport within the great valley. Though, as has been pointed out, most of the ports are unsuitable for large ocean vessels, a considerable amount of interstate and local traffic is carried on (e.g., in metals from Ports Pirie and Wallaroo, and salt from Edithburg) in ketches and coastal steamers. It has been largely owing to this gulf trade that railway communications have not been used to the fullest possible extent in the great valley. It will be noted from Fig. 1 that there are no railways on any portion of Yorke peninsula, except the extreme north, and that the west coast of Spencer gulf is absolutely dependent upon sea communication. Even on the east side of the gulfs, between Ports Pirie and Augusta, there is no coastal railway communication. It will be noticed, however, that in some of these cases, there is a very low rainfall.

The intermittent flow and steep descent of the valley rivers exclude all possibility of inland waterways, a serious loss, as water transport is often cheaper than rail or road traffic. For these reasons early drawings of Adelaide, which pictured ships at anchor behind the present Parliament House, have not materialized, and if it has not been worth while to canalize the Torrens for the traffic of the capital, it is obvious that no other scheme will be worth the expense. It is unfortunately impossible to link the great valley with the Murray Basin (cf. the canal systems of Europe), and Professor Taylor has shown that the idea of connection with Lake Eyre is absurd. (Chapter V.) At the same time, South Australians should not neglect any possibility of water traffic, nor forget the very true dictum that "riverless lands have everywhere experienced an exaggerated and precocious railway development, and have suffered from its monopoly of transportation."

Roads of the valley show the ease of communication in flat areas. In mountain regions made roads over selected gradients are practically essential for regular traffic, but on plains numerous and unmade tracks are frequently used, even in a fairly advanced stage of development. The first regular road laid in the state—between Port Adelaide and the capital—ran straight across the plains. Owing to the popularity of the hills with the early settlers, and the consequent necessity of a regular route, the next road—that to Mount Barker, 1841-42—was constructed even before the Gawler road was made. To the latter place ran numerous tracks, uniting at the Para ford and bridge. A regular road was not built until after 1845.

The same facts may be noted to-day. The roads of the Adelaide plains run in direct lines from place to place, those of the neighbouring highlands wind round the scarp or follow up favourable valleys. Rivers and creeks, whose valleys are so useful for communication in the hills, run only intermittently, and cut deep and largely useless gorges, which are dry in summer and raging torrents in winter.

Railways are far more dependent upon physical features than are roads, as is shown by the fact that there was considerable railway mileage

in the great valley and other parts of the state long before the central highlands could be traversed. The first line opened in the area was the Adelaide-Port Adelaide railway (1856), and as settlers had by then realized the value of the northern plains their simplicity of contour was utilized to spread lines northwards to Smithfield and Gawler (1851), Roseworthy (1860), and Port Wakefield (1869). Instead, however, of continuing northwards along the plain, the lines were attracted to the rainfall and mineral deposits of the highlands; for example, Kapunda (1870). The hills behind the capital continued to form a difficult barrier, and the Port Pirie–Gladstone railway and Port Elliot–Strathalbyn tramway were built long before the main line crossed the escarpment below Mount Lofty in 1883.

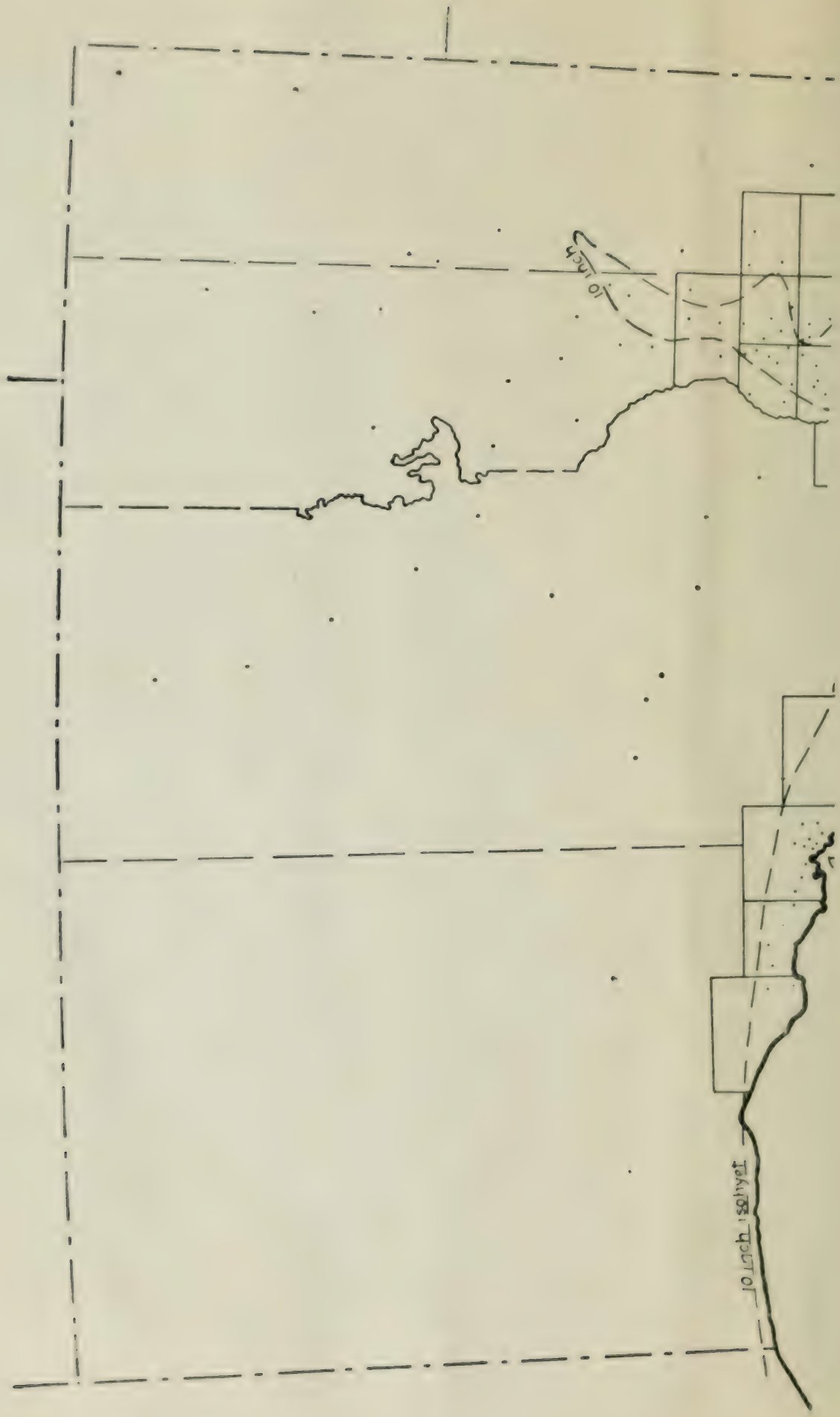
Now railways bring the greater portion of the state's products into the valley. Interstate goods and Murray basin wheat, wool, and fruits centre in Adelaide by the southern and Morgan lines, the latter penetrating the highlands by the Kapunda gate; Broken Hill minerals and highland wheat come to Port Pirie from the east; and northern pastoral products reach Port Augusta by two lines running into the interior. Fig. 1, which shows these railways, indicates the unfortunate breaks of gauge, which involve great expense in transhipping goods, and will present a serious menace in time of war. Thus in the great valley no less than three gauges are found: the standard state gauge, 5 ft. 3 in., from Willunga to Hamley Bridge; the 3 ft. 6 in. gauge on the Yorke peninsula, Port Pirie–Broken Hill, and Port Augusta–Quorn lines; the world's standard 4 ft. 8½ in. gauge on the East-West railway.

6. Population and Industries.

The most striking fact of the distribution of population in the great valley, as illustrated by Fig. 7, is the density on the eastern plains, particularly in the vicinity of Adelaide. This is due not merely to climatic considerations; it has been largely caused by a gradual growth and convergence of communications, with consequent trade and commerce, on the most favourable spot in the great valley. This process has been evident throughout the history of the state. Long before the foundation of the colony attention had been directed to the fertility of the great valley plains, which had been crossed by Barker, who pushed up the Sturt creek valley to Mount Lofty before meeting his death at the hands of the natives of the Murray mouth (1831). Thus Sturt wrote about 1832: "A spot has at length been found upon the southern coast of New Holland to which the colonist might venture with every prospect of success. All who have ever landed on the eastern shore of St. Vincent gulf agree as to the richness of its soil and the abundance of its pastures."

When the first settlement was moved from the poor soil of Kangaroo Island in 1839, it was natural that the settlers should proceed up the valley to the eastern plains. At Holdfast Bay there was a small boat harbour and fresh water behind the sandhills, but Port Adelaide was soon discovered and substituted for the exposed Glenelg anchorage.

Before selecting the site of the capital city, Colonel Light, the first Surveyor-General, with whom alone the decision fortunately lay, thoroughly examined the Murray mouth, Encounter Bay, Port Lincoln, and other possible places. He selected the present position of the city as being situated in good country, on rising ground, near fresh water, and within easy reach of the sea. "Because," as he wrote, "it was on a beautiful and gently rising ground and formed altogether a better connection with the river than any other place." In fixing this site, Light overcame strenuous opposition, including that of Governor Hindmarsh, who wanted the capital first at Encounter Bay, and later at


Loch Ness
Loch Lochy

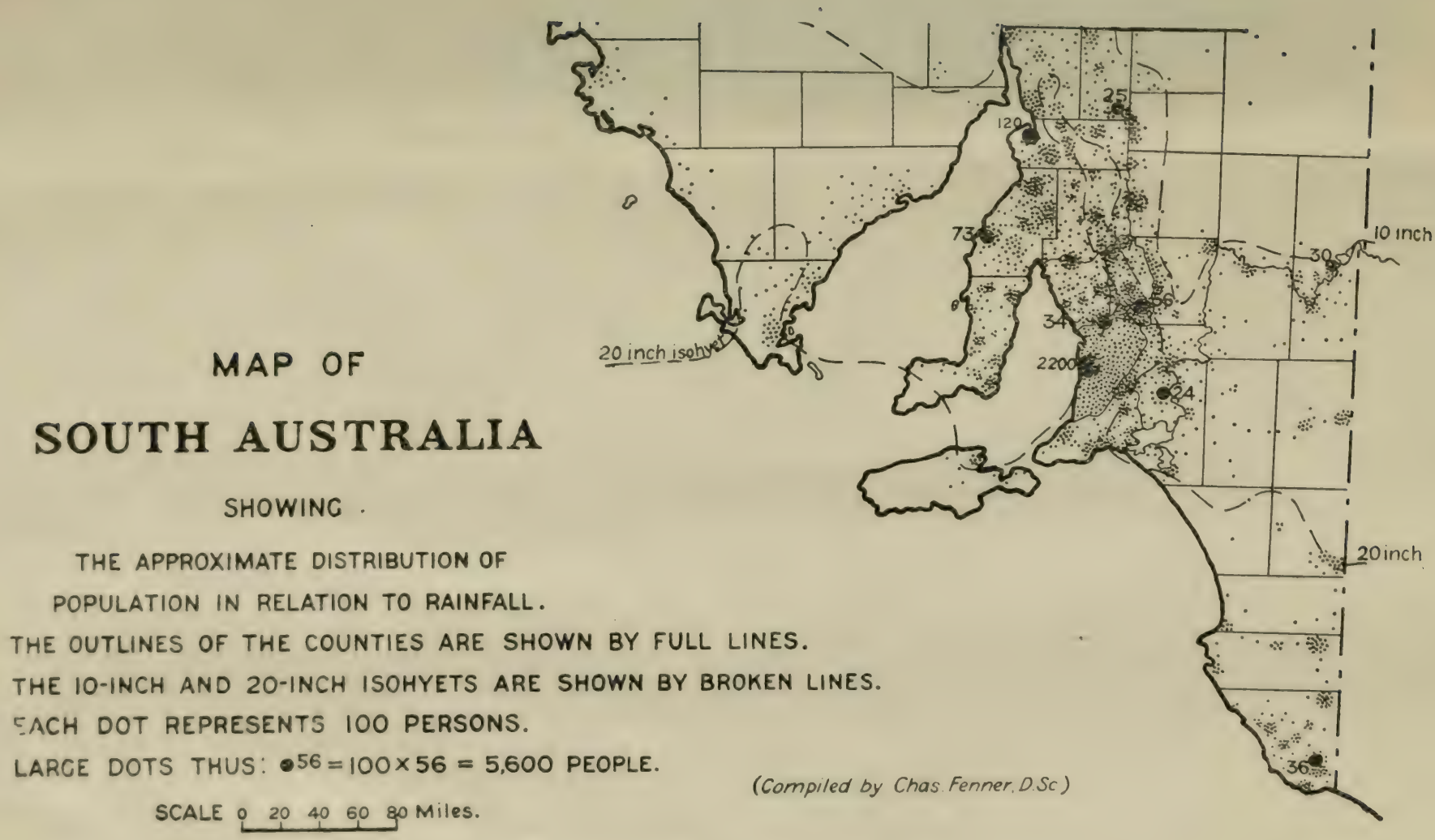


Fig. VII.
(Population figures for 1918.)

a spot lower down the Torrens, where Light saw that the river overflowed its banks. Posterity has justified the Surveyor-General's choice. An excellent climate, with fair rainfall, rich soil on the plains and highlands, mineral wealth in copper, easy communications to the north and north east, and fair artificial harbours in the Port Adelaide estuary, have drawn to the capital area more than half the population of the entire state. This zone is the one really great commercial, manufacturing, and political region in South Australia, and, owing to the lack of good harbours, both in the great valley and beyond, is unlikely to find any rival, except the seaport which must some day arise as the outlet for the rapidly developing Murray basin.

At present the pre-eminence of Adelaide is simply overwhelming. Out of a total state population of 494,000 the capital area contains 255,000 (1921), nearly 52 per cent. Port Pirie, the second town and commercial centre, contains 9,800 people, a percentage of under 2½ per cent. In the period 1916-20 the oversea trade of the three leading ports was averaged as follows: Port Adelaide, £12,000,000; Port Pirie, £2,000,000; Wallaroo, £1,000,000 per annum. It is not altogether certain how far this huge concentration in population is good for a state whose industries, owing to the absence of black coal and water-power, are at present mainly of the primary producing type.

The city itself was laid out by Light amidst financial and labour difficulties, which largely contributed to the early termination of his life (1840). To this great martyr of South Australian history Adelaide owes its splendid position and plan. The principal fault the city possesses—the crowding of business to the narrow northern streets instead of the broad thoroughfares round Victoria Square—has been due to early conditions, when Torrens water was important and North Adelaide was the only suburb.

The distribution of population and industry within the city and suburban area is a further evidence of geographical control. On the seaward margin of the plain, with its poor sandy soil, are centres of population, such as Glenelg and Henley Beach, which are residential areas owing their importance almost entirely to their proximity to the sea. Port Adelaide, on the other hand, is on the landward side of the coastal strip, and is built on a recently elevated beach where residence is possible. Few people as yet live at the Outer Harbour.

Behind the seaward margin, on land recently reclaimed from the sea, and in places still liable to river floods, are pasturing areas, with occasional residential centres scattered along the railways and roads leading to the capital. At Port Adelaide, and close to the capital on the seaward side, are manufacturing areas which will be noted later, while to the north, east, and west are residential suburbs, whose extent has rapidly increased with the introduction of electric trams and motor traffic. On the upper slopes of the plain, and beyond most of the suburban areas, rainfall increases and population lessens. Here begin the vineyards, orchards, olive plantations, and market gardens of the escarpment, with sure rainfall and handy markets.

Owing to transport facilities and inland communication the majority of this great population is supported by commerce and manufacture. The reasons for the commercial supremacy of the capital area have already been discussed, but the manufacturing industries require explanation, as their existence is not only due to geographical, but to political considerations. It is the general policy of Australia to produce and manufacture at home all possible commodities, rather than to export her raw materials for manufacture elsewhere and to be later imported as finished goods. Thus home manufactures are protected by means of high

duties on imports, which have led to a great growth of manufactures in the Adelaide region, where raw materials centre, coal for power can be fairly easily imported, and a market is close at hand.

Although, as indicated above, most of these industries are in the capital zone, their local arrangement needs some comment. The main manufacturing area is situated between Adelaide and the sea, where land has been little prized for residential purposes and coal and goods can be transported easily to and from the water-front. Here such centres as Bowden, Hindmarsh, Kilkenny, Islington, and Port Adelaide engage in the manufacture of woollens, machinery, bricks, pottery, glass, phosphates, railway engines, etc. In some respects manufacture seems to be moving on to the water front itself—e.g., the Adelaide Electric Supply Company's new power station at Osborne and the Cement Company's works. It may be noticed that subsidiary manufactures frequently spring up around a main industry; for example, the glass works of Hindmarsh are largely dependent upon the coke of Bowden, and the Hume piping on the cement works.

In spite of the pre-eminence of the manufactures of the capital, the presence of raw materials and transport facilities makes local manufactures possible in various parts of the state. Thus the ores of Broken Hill and the Wallaroo-Moonta mines are smelted at Port Pirie and Wallaroo. Phosphate deposits, and sulphuric acid from the copper mines, have led to superphosphate manufactures on Yorke peninsula. Salt is refined near the Yorketown and Wakefield salt lakes. Flour is milled in various local centres, and wine made on the vineyards—e.g., at Reynella. In some places even a great local demand has overcome the difficulties of transport, both for raw materials and coal. Thus Gawler and Mannum are able to manufacture agricultural machinery.

Beyond the capital area the population and industries of the great valley are determined by climatic considerations (of which the chief is rainfall), command of communications, and mineral wealth. It will be seen (Fig. 7) that commerce and mining lead to denser concentrations of population than do agricultural and pastoral industries. Thus Port Pirie (9,800), the second town of the state, owes its importance largely to its position in relation to a geological control at a considerable distance—i.e., to the fact that it is the nearest satisfactory harbour to the Broken Hill silver, lead, and zinc mines, 250 miles to the north east. In this industry it has proved economically possible to bring Newcastle coal to Port Pirie, and a vast smelting business has arisen. The town has also collected considerable export trade in wheat and pastoral products, owing to its communications and nearness to the highlands and 20 inch isohyet. In 1918-19 exports totalled £1,100,000; in 1920, £3,800,000.

A second very dense area of population, also due almost entirely to geological control, in this case near at hand, is found in the group of mining and agricultural towns to the north of Yorke peninsula. Here Wallaroo (3,300 people), Moonta (1,300), and Kadina (2,500), like Port Pirie, owe their existence largely to mining, in this case to the wonderful copper deposits of the area. The total mineral wealth produced in the state to 1920 was £39,000,000, and of this £26,000,000 was copper. The greater portion of this came from these mines, which averaged over £600,000 worth of copper annually from 1916-20. As in the Adelaide area, the main industry has led to a growth of subsidiary production. In this case the sulphuric acid of the copper trade has attracted phosphates from the Pacific islands for the manufacture of superphosphate. Although a large proportion of the population of these towns is engaged in mining and smelting, the surrounding country is a rich wheat and sheep area, and the towns are noteworthy centres for these industries.

Two other places in the great valley owe their importance to somewhat special conditions. The first of these density groups can be seen from Fig. 8 to be centred round Port Augusta (1,800), at the head of Spencer gulf. This town has a commanding position in the north of the valley, where it can collect the exports and imports of the wheat areas to the east and the arid pasturing country behind it. It is connected to the great northern railway by the Pichirichi pass to Quorn, and is increasing in importance as the break-of-gauge town on the East-West line. A second population group, centred in southern Yorke peninsula, owes its importance largely to a number of salt lakes near Yorketown (500). These shallow lagoons have been formed by the partial removal of local limestone leaving a pan of glacial clay, which collects the drainage of the surrounding country. When this water, which contains soluble salts, evaporates, a crust of salt and gypsum is left behind; this is scraped up during the summer months for commercial purposes.* Edithburgh (800) is the port of the area.

Apart from these special areas of density due to communications, mining facilities, etc., the population of the valley is mainly distributed with regard to rainfall, the general trend showing a rapid decrease with the isohyets. This is due to the fact that throughout the whole area, other than in the regions specially discussed, the population is supported by agricultural and pastoral industries, which depend almost entirely on the quantity and reliability of the rainfall (Section 4). Here, as in all steppe areas (winter grass lands) devoted to such industries, population is more scattered than in industrial regions. It will be noticed, however, that concentrations occur in numerous small centres which possess advantages of communication or commerce. Thus Gawler (1,800) is important because it is a convenient market town for the rich agricultural lands around the Para river, and because natural routes from the Barossa ranges converge upon it. Maitland (Yorke peninsula) is the centre of a valuable agricultural region, where rainfall is heavier than in the surrounding areas. Port Wakefield, at the head of St. Vincent gulf, Port Germein (Spencer gulf), and Port Victoria (Yorke peninsula) are valuable ports for local trade, which is carried on almost entirely by sailing vessels.

The chief agricultural industry of the great valley, as of the whole state, is wheat growing, though the yield is not quite as great as in the wetter highlands to the east. Figs. 8 and 9, however, illustrate how important it is in the area. Thus for the period 1916-20 County Fergusson (southern Yorke peninsula) has averaged over two million bushels a year (15.6 bushels per acre), Daly (northern Yorke peninsula) over 3.5 million

*The industry is also carried on in the great valley at Lake Bumbunga, near Port Wakefield, and by solar evaporation of sea water at Price, on the east of Yorke peninsula, and near Port Augusta. The last-named works are at present closed. Gypsum, which is used in the production of cement, fertilizers, plaster of paris, flux, and other purposes, is also important in the great valley. An industry with considerable possibilities is the production of alkalies in connection with the salt production. With this object the Standard Salt and Alkali Company has established at Edithburgh one of the first plants to operate in Australia for the production of alkalies, caustic soda, etc., and products extensively used in the soap, glass, textile, paper, and other trades.

The immense importance of evaporation in the salt industry is worthy of notice, and is largely responsible for the ease with which South Australia can work her salt lake and gypsum deposits, which are of a "magnitude, purity, and accessibility unrivalled in Australia." Most of the state possesses an evaporation of from 50 to 100 inches a year, or deducting rainfall, of from 30 to 80 inches. The gulfs penetrate far into the high evaporation regions, and provide both sea transport, and water for solar evaporation from 30 per cent. to 50 per cent. more saline than ocean water. At present South Australia easily predominates in the salt markets of the Commonwealth, and as the state has over six million tons of lake salt alone in sight, without counting lake Hart, the industry has great possibilities. In 1919-20 the export of salt was 100,000 tons, largely for the meat preserving industries in Queensland, New South Wales, and New Zealand.

bushels a year (14.6 bushels per acre), and Gawler (the Gawler area) 1.75 million bushels per annum (14.3 bushel per acre). The quantity produced varies rapidly with rainfall. To the north of the valley the wheat areas follow the isohyets into the hills. The regions in the valley around Port Augusta only average 3 bushels per acre. More detailed particulars in regard to the wheat industry are given in Chapters II and VI.

Other agricultural industries are also important. Like wheat, they vary with rainfall, both in type and value. Oats and barley, which require a somewhat moister climate than wheat, are important in the south.

Southern Yorke peninsula and the Gawler area produce the chief quantities of barley, Yorke peninsula of oats. Hay is also important over most of the area.

Fruits are mainly of the Mediterranean type—e.g., the vine, the orange, and the olive. The vine is properly found on the escarpment edge (Chapter II), though practically all the vineyards lie below the 500 ft. contour line in the heavier rainfall areas. The olive grows without irrigation wherever rainfall exceeds 20 inches, but has been little cultivated. Citrus fruits grow luxuriantly in such areas as around Salisbury and along the Torrens, where water supplies are available. Such fruits as peaches, apricots, and nectarines, which require warmth, flourish.

Vegetables similarly show the influence of climate. Peas, beans, etc., can be grown in the winter, but in the summer artificial water supply is necessary if the valley areas are to compete with the neighbouring hills, although marrows, melons, etc., can generally be grown unaided.

On the whole, however, the valley is not a market gardening zone.

The same climatic control applies to forestry. It has been stated that this industry can flourish anywhere within the 20 inch isohyet, and parts of the valley would probably be suitable. When South Australia was first settled the plains were heavily timbered south of Adelaide, as such names as Forestville and Black Forest suggest, while to the north heavy timber was only found along the watercourses. Such woods as existed, however, have been rapidly destroyed, except on the mallee areas of Yorke peninsula. Land, however, is so valuable for wheat and pasturing in this area that there is little chance of forestry becoming an important industry.

In regard to pasturing, the chief animals are cattle and sheep, whose distribution can be seen from Figs. 10 and 11. Cattle are greatly concentrated in the Adelaide region, owing to the city dairying industry. This area averaged about 28,000 per annum (1916-20); at least five-sixths of the number were dairy cows. To the north cattle decrease rapidly, as the land is more highly valued for wheat and sheep. Thus the Gawler area and northern Yorke peninsula each averaged only 7,000 to 8,000 a year. There are very few in the north of the valley. Sheep are far more evenly distributed than wheat or cattle, being less dependent in this region upon the isohyets or nearness of the capital market. The Adelaide and Gawler areas each averaged over 120,000 (1916-20).

Higher up the valley northern Yorke peninsula averaged about 200,000, while even round Port Augusta over 50,000 were found.

7. Water Supply.

Concentration of population, such as exists in the great valley, where the greater portion of the country has a rainfall of 20 inches and under, and most of the fall occurs at one season of the year, implies very considerable water conservation. As will be shown in greater detail in the following chapter, the highlands not only receive heavy rainfall, much of which ultimately finds its way to the valley, but also provide catchment areas and reticulation by gravity for water conservation and distribution. This is chiefly effected by the construction of reservoirs, which do much to

compensate for the comparative uselessness of the rivers to the valley. The highlands also supply portions of the Adelaide region with artesian, sub-artesian, and ground water, which sinks into the surface on the hills and follows hard rock down below the plains, where it is tapped by wells and bores at various depths.

CHAPTER II.

THE CENTRAL HIGHLANDS.

1. Physiography of the Highlands.

This area of South Australia, which from the point of view of primary industries is probably the most important, is neither of great size nor altitude. It contains some 30,000 square miles of 500 ft. land only, and nowhere attains a height of 4,000 ft. In shape this division may be roughly compared to a cornucopia or horn. In the south, Kangaroo Island forms the point of the horn, separated from the main body of the highlands by the important Backstairs Passage "gap." Across this strait, on the mainland, is a gradually widening plateau from which rise various ranges, e.g., the Mount Lofty, Barossa, and northern and southern Flinders. North of Peterborough the plateau divides into two arms, a higher area on the west, which follows the great valley to the Lake Eyre basin, and a lower, stretching away to the New South Wales border in the vicinity of Broken Hill.

In the south the plateau is some 30 miles wide, and reaches in Mount Lofty a height of 2,334 ft. In the north it is considerably wider, and the ranges are of greater height. Thus St. Mary's Peak, near Hawker, attains 3,900 ft., and several peaks south of Quorn—e.g., Mounts Brown and Remarkable—are over 3,000 ft. Between the Mount Lofty, Barossa, and the Southern Flinders systems lies a gap of 1,000 ft. land, the Kapunda gate, one of the most important economic points in the physiography of the state.

The central highlands mainly consist of uplifted blocks of an ancient peneplain, caused by the weathering of former regions of greater height. This wearing down is carried out by such agents as rain, frost, wind, ice, etc., which waste the highlands away, and lead to the transport of material from the hills to the plains, and a general levelling of the surface, as in central Australia. In the South Australian highlands a recent re-elevation has occurred, and the weathering forces have not had sufficient time to wear the escarpments or edges into gentle slopes. The peneplain thus presents steep scarps to the great valley and less steep slopes to the Murray basin, making communication most difficult. Again, in older highland areas, the agents of denudation wear gentle sloping valleys of great assistance to man. Ice in particular is very powerful in this respect. In the central highlands, however, although weathering has been effected by seasonal rivers, such as the Onkaparinga, Torrens, Gawler, and Light, these comparatively young and intermittent streams have only succeeded in cutting steep gorges in the escarpment.

Even in this small area, however, differences of erosion appear between the southern highlands, rounded by a fair rainfall, and the Northern Flinders ranges, with considerably sharper outline. Owing to low altitude and latitude, ice, which could have provided glaciers, permanent rivers, and rapid denudation, has not been present for long ages.

For these reasons the central highlands affect man in South Australia, though to a lesser extent than in other parts of the world, where occur greater mountain regions, such as the European Alps, Himalayas, East African plateau, or East Australian divide. The first three are huge enough to act as definite climatic, racial, and commercial barriers, while the last, though not a racial bar, enormously influences climate and communications.

At the same time the central highlands of South Australia possess climatic, topographical, commercial, and industrial characteristics sufficient to provide striking contrasts to other South Australian regions.

Note. The geological history of the central highlands is of particular importance in its present effect on population. In very early times South Australia stretched far to the south, and to some extent the main ranges ran east and west. These mountains, which were largely worn away by the action of ice, can still be traced near Victor Harbour, and on Kangaroo Island, Yorke peninsula, Eyre peninsula, and at other places. Early glacial action, which operated from south to north in such areas as the Inman valley, still affects population by the rich boulder-clay soils it has left at Hog bay, and by the impervious clays of the Mt. Compass swamp lands and of the salt pans of Yorke peninsula.

In later times, in place of these ranges, a plateau was formed, stretching far to the south of the present state, with a gentle slope from north to south. Great longitudinal valleys were cut in the area by southward flowing rivers. The valleys of these "dead rivers" still greatly influence human life as communication routes. (Section 4.)

At a still more recent date, further movements elevated the whole south and east of Australia, and depressed the central regions. As a result a new east-west divide was formed near Peterborough, which cut the old drainage off from the sea and formed the shallow lakes of the central depression. The plateau afterwards broke into blocks, portions of which slipped down in troughs, such as the great valley and Murray basin. This faulting is very obvious near Mount Lofty, where Waverley ridge represents the old peneplain, and the Belair-Blackwood, Glen Osmond, and Adelaide shelves, different fault steps, while 2,000 feet below sea-level is another block buried by marine and highland deposits. These movements helped to create the great valley plains, and made important economic gates (i.e., the Kapunda gap) between the Mount Lofty, Willunga, Barossa plateaux, and similar blocks of the old peneplain. River drainage was also greatly affected; such old rivers as the Torrens and Onkaparinga, flowing in well-graded valleys, were uplifted and compelled to cut steep gorges or alter their courses to retain outlets to the sea. Thus the Torrens flows in its upper course through its old gently sloping valley, while in the middle course it has cut the deep Torrens gorge. (Section 4.) According to Professor Howchin, the Onkaparinga, on the other hand, has left its old course down McLaren Vale to Port Willunga to cut a difficult channel through rugged country to Noarlunga. All these changes have greatly affected man's industries and communications.

2. Coastline of the Highlands.

The shore line of the central highlands is very short, and, like most plateau coasts, causes peculiar economic difficulties to mankind owing to the fact that it presents to the sea a steep, unbroken front, on the whole without good harbours or easy inland communications. Its rugged and beautiful scenery, however, forms a striking contrast to the monotony of the great valley coastline.

Because of the narrow width of the plateau, and its coastal plains on the west, the amount of actual shoreline is exceedingly small, while, owing to the solidarity of the southern region, it is practically unbroken, as is illustrated by Fig. 1, where the 500 ft. contour line may be seen to follow the shore closely, except over a portion of Kangaroo Island. The only promising port is Victor Harbour, amongst the ancient granitic rocks of the old east-west ranges, though it is possible that, within St. Vincent gulf, the "marino" area could have been utilized for the construction of a deep-water port for Adelaide. Victor Harbour (1,800 people) has fair inland communications up the Hindmarsh and Inman valleys, and satisfactory routes for rail, road, and possibly canal, exist along the plain to the Murray mouth (Fig. 1). Considerable sums of money have already been spent here, and if further works are carried out there are prospects

of this place becoming, as it naturally should, a great harbour for the Murray basin. It may be noticed, however, that in spite of its popularity as a seaside resort, future prospects, and river valleys penetrating the hinterland, no direct railway line has been constructed to Adelaide, viâ Willunga or the Meadows.

3. Climate of the Highlands.

The climate of the central highlands, like that of the great valley, is Mediterranean in type, but, as in most elevated regions, is cooler and moister than the neighbouring lowlands. Unfortunately no detailed temperature map of the state is available, but it is estimated that the southern hills are, on an average, some 10° lower in temperature than the neighbouring plains. This is borne out by the fact that Fig. 2 (Annual Temperature Range) shows a decided northerly loop over the highlands, indicating a lower range of temperature and more equable conditions. It is probable, however, that both in mean temperature and range the vast bend of the Bight exercises greater influence than the highlands. Apart from differences of temperature, however, it is certain that, as in all highland areas, more rapid radiation leads to cooler nights. This fact largely accounts for the growth of semi-suburban areas in the hills adjoining the capital.

The causes of the South Australian rainfall have already been outlined in Chapter I. As in the great valley, the main rainfall of the plateaux is a winter one, due to the Antarctic depression and westerly winds. Also, as in the great valley, and for similar reasons, rainfall shows a marked decrease towards the interior; but in this case a new element, that of varying elevation, is introduced, as the hill slopes or ranges cause the air blowing athwart them to rise and expand, and as a consequence the temperature may be reduced below dew point with cloud or rain. This is clearly illustrated by Fig. 4, which shows that Kangaroo Island is mainly a 20 inch area, and that concentric belts of rainfall, 20 inch, 25 inch, and 30 inch between them cover the whole area of the highlands from Backstairs Passage to the Kapunda gate. Of these belts, the 20 inch covers part of the great valley plains, the 25 inch closely follows the escarpment edge, while the 30 inch only embraces the highest land of the Mount Lofty and Barossa ranges. In this area the heaviest rainfall of the state occurs on the highest point of the southerly ranges, where Mount Lofty summit averages over 47 inches per annum. North of the Kapunda gate, the greater part of the highland rainfall averages from 15 inches to 20 inches, until within a few miles of Port Augusta. Here again the heaviest precipitation is found on the highest land. Thus in the hills around Clare and Georgetown there is a 20 inch area, which exceeds 25 inches over a small part of the former region. Between Port Pirie and Booleroo Centre is a similar district on the western buttress of the plateau, where Mount Remarkable rises over 3,100 ft. North of Port Augusta there is only one 15 inch area, in the highlands north of Quorn; the plateau and the northern Flinders ranges, however, push the 10 inch isohyet far into the interior.* It will be seen presently that this distribution of rainfall is the principal influence upon man and his industry in the area.

Note. Detailed figures indicate the importance of altitude and distance from the open seas in deciding the respective rainfall of various places. Calculating from a line drawn from Port Elliot, via the south coast of Kangaroo Island, to Port Lincoln, we find a steady decrease inland, varied considerably by elevation. Thus Port Elliot (altitude

*The variability of this highland rainfall over the twenty years 1900-1919 may be seen from Fig. 6b, which illustrates the fall in county Stanley, the Clare area. It will be noticed that the extremes vary from 31 inches in 1917 to 9 inches in 1914.

77 ft.) has a rainfall of 24.5 in.; Kapunda, 80 miles (803 ft.), 19.6 in.; Peterborough, 180 miles (1,747 ft.), 12.9 in.; Hawker, 260 miles (1,033 ft.), 11.9 in.; Beltana, 320 miles (775 ft.), 9.3 in. How important is the effect of altitude may be seen in the vicinity of Mount Lofty, where Belair (1,009 ft.), Stirling West (1,628 ft.), and Mount Lofty summit (2,334 ft.) have respective rainfalls of 28.13 in, 45.9 in., and 47.3 inc. Again, Clare (1,300 ft.) has 24 in. of rainfall, while Bungaree (950 ft.), six miles distant, has only 22 in. Similarly, the fall at Quorn (961 ft.), 13.4 in., can be compared with that of Port Augusta, 9.3 in.

4. Communications of the Highlands.

The communications of the central highlands illustrate, as nowhere else in South Australia, the importance of natural features to human intercourse. As has been previously stated, many early settlers favoured the hills—e.g., the great explorer Eyre had a station at Kapunda as early as 1839, and the Mount Barker district was settled by the same year. This, and the fact that traffic in mountainous areas is closely bound to a few natural routes, led to a rapid growth of highland communication. For example, the main Mount Barker road was surveyed in 1839 and completed in 1841.

This road, the chief artery between the capital and neighbouring plateaux, is an excellent example of highland communication, and is typical of many others that ascend the escarpment. In this case various routes converge across the plain to the mouth of the valley carved by the Glen Osmond creek, which is closely followed to the "Devil's Elbow." Here the new road abruptly leaves the valley bed, and winds round the scarp face to a level area, probably part of the Blackwood-Belair shelf. From this plateau a steep ascent is made to a second shelf on the same level as the Waverley Ridge plateau mentioned above. From here the road enters the valley of the Aldgate creek, which is largely utilized for the descent to the Onkaparinga valley. At the "Devil's Elbow" may be noted the old road, which ascended a steep gully instead of following the scarp. Similar examples of physical control are found throughout the highlands. Particularly interesting are the roads, which are in a sense dependent upon the older rivers. Thus the Adelaide-Mount Pleasant road for long avoided the difficult Torrens gorge in favour of a steep scarp ascent and deep cutting at Tea Tree Gully, but used the ancient valley of the upper river for many miles. Similarly, the young course of the lower Onkaparinga, between Mylor and Noarlunga, is useless for communication, but the upper valley between Ambleside and Woodside is of great value.

Railways are far more dependent upon physical features than roads, owing to the necessity for easier gradients and curves. The highland railways of the state demonstrate the fact that difficulties of communication are considerable, but less severe than in many mountain areas. In South Australia three great railways cross the divide from west to east within a distance of a hundred miles, while the main northern line actually ignores the great valley and follows the well-watered highland region from Hamley Bridge to Leigh's Creek, a distance of 120 miles. This may be compared with the eastern Australian highlands, where only five railways cross the divide between Melbourne and Brisbane (over 800 miles), and where, even in much of the coastal region, lateral railway communication is impossible.

Notwithstanding these facts, the difficulties of railway engineers in the central highlands have been considerable. On the whole, the eastern scarp has been easier to traverse than the western, and the northern highlands than the southern. Thus the Port Elliot Goolwa tramway reached Strathalbyn from the south east in 1868, whereas the western scarp was not crossed by the main Adelaide-Melbourne line till 1883. Again, while the latter line takes eight tunnels to ascend 1,600 ft., the northern line can reach a height of 2,000 ft. without a single tunnel by

the use of longitudinal valleys created by the dead rivers mentioned above (Section 1).

The main lines crossing the escarpment are of 5 ft. 3 in. gauge in the Mount Lofty and Barossa Ranges, and 3 ft. 6 in. in the Flinders area. It is somewhat curious that the break of gauge in the highlands (Terowie) occurs fully 80 miles further north than in the great valley (Hamley Bridge). The fertile southern areas are well served except in the extreme south, and branch lines are springing up—e.g., to Mount Pleasant, Angaston, and Spalding.

The railway lines of the highlands illustrate much the same physical control as do roads. Hence the main Adelaide-Melbourne line is a scarp railway as far as the Blackwood-Belair plateau, tunnelling through the spurs and crossing the deep gullies on embankments. After a comparatively simple path across this plateau (e.g., the straight mile), it follows the Long Gully and Upper Sturt valley through the Mount Lofty station gap to the Aldgate creek and Onkaparinga valleys. The importance of the Kapunda gate to the Morgan railway, and of the Pichirichi pass to the Port-Augusta-Quorn line, has already been mentioned.

5. Population and Industries of the Highlands.

Distribution of population in this region differs greatly from that of the great valley. In the former area coastal plains, fair harbours, and economic minerals have led to dense concentration of population in favourable centres, but whereas these are missing in the latter region a higher rainfall and exceedingly fertile soil have led to a very considerable settlement by an agricultural and pastoral population. (Fig. 7.)

Of this settlement rainfall is the chief controlling factor, owing to its influence on agriculture and pasturing. Scattered over the area are, of course, small towns, which occupy favourable positions for the collection of local products or the distribution of imported goods. These may be railway junctions and centres, etc., e.g. Peterborough (2,200), Strathalbyn (1,000), Jamestown (1,400), Eudunda, etc., or simply road centres (e.g., Echunga). One or two which have arisen primarily as mining centres (e.g., Burra, 1,800, and Kapunda, 1,600) have become important agricultural and pastoral towns (cf. Bendigo, Ballarat, etc.). In a few cases also centres which have particular local facilities, engage in manufacture—e.g., the woollen industries of Tweedvale, the flour milling of Truro, and wine distilling of Angaston. Practically all manufactures, like the three mentioned above, are concerned with primary production. Outside these small centres of density, it may be said that population is scattered according to the main agricultural and pastoral pursuits, agriculture, as in 'the gregs' valley, supporting more people to the square mile than pasturing. Owing however to the prevalence of mixed farming it is difficult to calculate the relative effect of these pursuits.

The main agricultural industry of the central highlands is wheat growing, and the area produces more wheat than any other geographical division of the state. The region is one of the most suitable areas in the world for the industry, as the soil consists largely of fertile loam—a mixture of clay and humous matter—while rainfall is usually sufficient for the crop, but not heavy enough to wash the nutriment from the ground.

Wheat requires rain after planting, warm sun when ripening, and a firm soil to support the heavy head when the corn is in the ear. South Australia, with its warm dry summers and mild moist winters, ideally fulfils these conditions. The land is ploughed when softened by the autumn rains, the grain sown in the early winter, and, after being watered by the winter and spring rainfalls, is reaped in the heat of December and

January, full benefit being thus derived from the Mediterranean climate. Besides these factors, the wheat-grower has, in many cases, the advantages of quantity production with scientific machinery, such as multifurrow ploughs, cultivators, drills, strippers, and harvesters. Two of these inventions, the stump-jumping plough, which saves the heavy expense of grubbing by rising over roots, and the stripper, are South Australian in origin. With such mechanical aids it is estimated that one man with a team of eight horses can work from 200 to 250 acres of wheat land, with some little assistance at harvest time.

Figs. 8 and 9 illustrate the importance of the central highlands in this production. It will be noticed that here, as in the great valley, the total return and the yield per acre decrease with the isohyets. It can be seen, however, that in some cases local conditions alter this rule—e.g., in the higher areas of the Mount Lofty ranges, where neither soil nor climate are suitable. On the whole, the richest wheat area of the division, and

Fig. VIII. South Australian Wheat Yield, 1915-16—1919-20. Each dot represents an annual average production of approximately 200,000 bushels. As far as possible the dots are placed in the portion of the counties where the chief yield occurred. (Based on South Australian Statistical Register. W. L. Johnston, Government Statist.)

indeed of the state, is the region of the highlands between Eudunda and Peterborough. Here two counties, which are mainly in the hills—Victoria and Stanley—each averaged between 3,000,000 and 4,000,000 bushels a year (1916-20), a return of over 17 bushels per acre. Northern Yorke peninsula (3.5 million bushels per annum, 14.6 bushels to the acre) alone reaches so large a total in the state. All over the central highlands

production is very heavy. Over most of the western and central portions of the plateau, as far north as Quorn, the 1916-20 average yield per acre ranged from 9 to 12 bushels, while north of Quorn a considerable region produced from 7 to 12 bushels per acre. In noticing the northerly limits of this yield, mention may be made of Goyder's Line of rainfall, drawn by Surveyor-General Goyder, who in 1865 marked out this natural boundary

Fig. IX. South Australia.—Wheat Yield per acre, 1915-16 to 1919-20 average. The shading indicates the chief portions of the counties where the chief production occurred. The yield per acre is that for each county as a whole. (Based on the figures published by W. L. Johnston, Government Statist.)

between the southern flora and the salt bush, blue bush, and mallee country. When the isohyets were properly charted this line was found to correspond closely with the 12 inch line of rainfall, and has always been regarded as an excellent indication of the limits of safe wheat farming. Owing, however, to improved methods of cultivation, such as dry farming and the use of superphosphates, the wheat zone has now been pushed out in many areas to the 6 inch winter and 10 inch annual rainfall isohyets.

After wheat, which is overwhelmingly the most important agricultural crop in the highlands, hay, barley, oats, the vine, fruits, and vegetables are noteworthy. Like wheat, the distribution of these products is mainly determined by rainfall. Hay, barley, and oats are found in most of the highland areas, except in the regions of low rainfall north of Quorn. The hay, which is mainly of the wheaten type, is grown all through the wheat districts. Barley has a somewhat similar distribution, but oats require a considerable rainfall, and are found in large quantities in the southern

highlands. In the same area field peas and beans are grown in connection with an important pig-rearing and bacon-curing industry.

The central highlands is the principal vine-growing area of South Australia, owing to climate and other geographical factors. The industry is one of the most important in the state, the average annual wine output (1916-20) being 475,000 gallons, valued at over £500,000 a year. (Chapter VI.) There is also a large production of drying and table grapes. The principal vineyards lie along the western slope of the Mount Lofty ranges, or are in the Barossa ranges—e.g., the Tanunda and Clare districts. The controlling factor is rainfall; most of the vineyards are within or near the 25 inch isohyet. Sloping land, which prevents stagnant water lying at the roots of the vines, and warmth such as is found on the western slopes, are also important. Most of the grapes in these areas are used for wine-making purposes; the drying industry is more important in the Murray basin. (Chapter III.) Although wine-making is carried on in the city manufacturing area, the largest wineries are generally found on the vineyards (e.g., Seppeltsfield, near Greenock, and Reynella). The industry is one of the oldest in the State; Reynella was founded in 1846.

Fruit-growing in the central highlands is similarly under geographical control. Owing to considerable climatic variations, a wide range of fruits is found in the area. On the whole, cool temperate fruits—e.g., apples, pears, plums, quinces, cherries, and numerous kinds of berries (e.g., strawberries on the hill slopes and raspberries in the creek bottoms)—flourish in the cooler, moister southern highlands. On the drier, warmer foothills, and in the more northerly regions, Mediterranean fruits—e.g., the orange, lemon, peach, apricot, and fig—are found. Nearness to the capital is an important factor in this industry, as there is a considerable market for the fresh fruits, both for immediate consumption and by jam factories of the suburban manufacturing areas.

Market gardening, like cool temperate fruit-growing, requires a moderate temperature and rainfall, and similarly benefits from handy markets. Hence the industry is mainly important in the southern highlands, which have also the great advantage of creek bottoms containing dark humous soil, which is excellent for vegetable growing of all descriptions. These economic factors have led to an important industry in such places as Piccadilly and Uraidla. Here the rainfall, which is almost sufficient, can be aided by the water of numerous wells and dams in the gully beds. The main products are root crops—potatoes, onions, turnips, carrots, etc.—pumpkins, melons, tomatoes, and green vegetables. Adelaide is, of course, the principal market, but there is considerable trade to population centres in arid regions—e.g., Broken Hill and Kalgoorlie.

Forestry is another industry which is closely dependent upon climatic control. Here again rainfall is the deciding factor, for heavy timber requires far more moisture than scrub lands or steppes. It has been estimated that the greater portion of the state, with a rainfall of over 20 inches, is suitable for forests, but the highlands, with 25 inches to 40 inches, are naturally the most satisfactory areas, particularly as large regions are unsuitable for agriculture and markets are fairly handy. The economic value of the native timbers, which are hardwoods, was unfortunately little recognized by early settlers, and wasteful and irrevocable destruction of forests occurred, which have left the state to face enormous future imports, if not an acute timber shortage. Such a prospect, already foretold by a great increase in prices, is a serious matter for a state whose coal resources, if existing, are totally undeveloped. In recent years the value of the forests has received more recognition, and a Woods and Forests Department, founded in 1875, has conserved forest areas and begun planting both native and exotic trees. The former, consisting of two groups, the eucalypts

and acacias, have great economic use, and are naturally suited to the climate, being able to withstand great heat and drought, owing to the possession of tough, leathery leaves, which secrete oil or can be slanted to the rays of the sun. The imported trees are mainly pines, soft woods which grow rapidly and are most useful for furniture, fruit cases, and many other commodities. It has even been said that South Australia has the greatest possibilities in Australia for softwood production.

In spite of all efforts, however, the forest areas are insignificant, by far the smallest in any Australian state. The total area at present is only 3,800,000 acres, or 1.56 per cent. of the whole state. This can be compared with Victoria, 20.9 per cent., or Australia as a whole, 4.86 per cent. There are at present about 40 forest reserves, embracing 160,000 acres. As would be expected, the most important of these are in the central highland area. Thus Bundaleer (8,000 acres) and Wirrabara (18,000 acres), two of the largest forests of the state, are situated in the highlands east of Ports Pirie

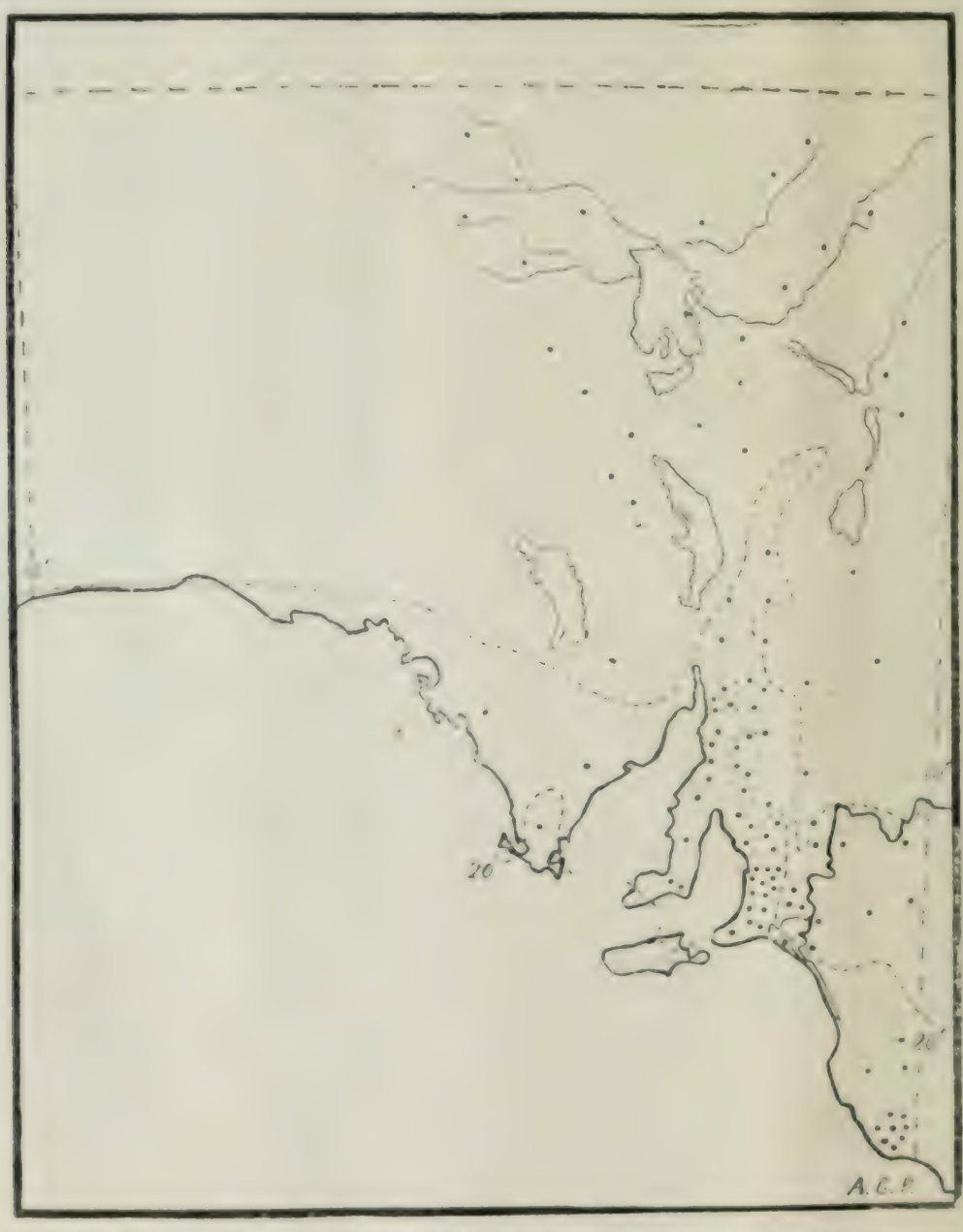


Fig. X. Distribution of Cattle, 1915-1916 to 1919-20 average. Each dot represents the approximate position of 3,000 cattle. Distribution is correct for counties, and as far as possible for smaller districts (hundreds). Outside the county area (see Fig. IX) distribution can be only roughly indicated. (Based on figures published by W. L. Johnston, Government Statist.)

and Broughton respectively. The former has a rainfall of 21.6 inches, the latter of 26.7. In the southern area of heavy rains are Kuitpo, near Meadows (11,000 acres), and Yankalilla. In the hills the production of wattle bark for tanning is also an important industry.*

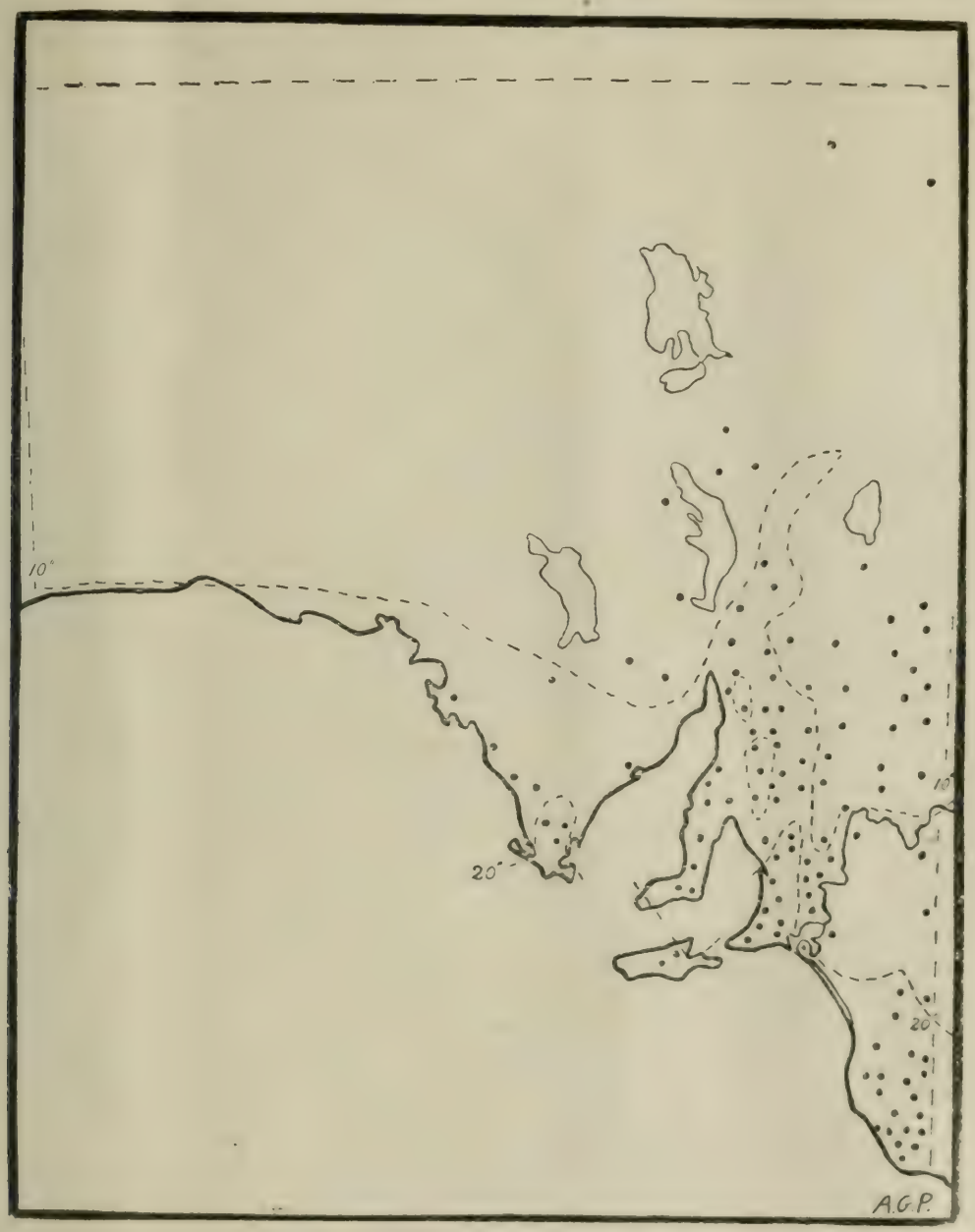


Fig. XI. Distribution of Sheep, 1915-16 to 1919-20 average. Each dot represents the approximate distribution of 50,000 sheep. Distribution is correct for counties, and as far as possible accurate for smaller districts (hundreds). Outside the county area (see Fig. IX) distribution can be only roughly indicated. (Based on figures published by W. L. Johnston, Government Statist.)

Pasturing in the central highlands, as in the rest of the state, is less dependent upon heavy and certain rainfall than is agriculture. Figs. 10 and 11 illustrate, however, that the region is a most important one for cattle and sheep. Distribution, as in other parts, shows a gradually thinning northwards with the isohyets. Cattle vary fairly closely with rainfall. They are numerous in the hill areas behind Adelaide, where the dairying industry is important. They are also found in large numbers in

*On Kangaroo Island, which still contains dense scrub lands, two minor forest industries may be noted. Xanthorrhoea, or yacka gum, is collected, as it contains picric acid, which is used for varnishes. Eucalyptus oil is also distilled from the leaves of the narrow-leaf gum.

the well-watered highlands north and south of the capital. Most of the region had from 11 to 14 cattle to the square mile (1916-20), of which a very considerable proportion were dairy cows.

Further north cattle are still fairly numerous, as far as the head of Spencer gulf—e.g., the highlands north and east of Port Pirie average about 6 per square mile. Here again there is a dairying industry, and a large proportion of dairy cows. In the drier northern portions of the highlands there are relatively few cattle, though there are some along the Broken Hill railway.

The distribution of sheep in the area is less strongly influenced by rainfall than that of cattle. Thus the highlands south of the capital (County Hindmarsh) in 1916-20 averaged some 175,000 per annum (about 170 to the square mile), while the highlands to the north around Kapunda (County Light) and Clare (County Stanley) contained 114,000 and 250,000 respectively, an average of about 160-170 per square mile. In the north there is relatively small reduction as far as the head of Spencer gulf; thus County Dalhousie (the region around Orroroo) averaged 120,000, about 100 to the square mile. North of this density rapidly decreases.* The principal flocks over these areas are Merinos, a type developed in the Mediterranean climate of Spain, and peculiarly fitted for South Australian conditions, under which they have produced an amazing wool-carrying capacity. Particularly in the south, the Merino is crossed with Lincoln and other meat-carrying varieties, in order to procure a crossbreed of value both for wool and meat. Throughout the area there is an increasing tendency to combine wheat-growing and sheep-raising in mixed farming, particularly since it has been found that superphosphates have improved the nutritive qualities of the stubble. As in the wheat industry, scientific crossing, etc., has enormously improved values—e.g., the amount of wool per fleece has increased from 4.4 lbs. in 1871 to 7.6 lbs. (1916-20 average).

Minerals are of relatively small importance in the central highlands, in spite of the age of the rocks and exposure by denudation. The Burra, Kapunda, and Blinman copper mines have been of considerable importance in the past, the first-named producing nearly £5,000,000 worth of ore (1845-1877). Small quantities of gold, silver, lead, bismuth, clays, french chalk, and other minerals have been mined in various places. Existing legislation is, however, a factor against the proper prospecting of the alienated highland areas. Unfortunately, no coal of great economic value has yet been proved in the region. Large seams of brown coal exist at Leigh's Creek, some 370 miles north of Adelaide, but the coal is of poor quality, the overburden considerable, and the cost of transport prohibitive. A further lignite deposit is being explored at Hope Valley, near Adelaide. The economic prospects of the state will be enormously increased if it is possible to utilize such lignite deposits for the production of electric energy. Another important mineral product of the plateaux is building stone, quarried to a great extent all over the highland area, as can be seen from the fact that stone houses predominate in the hills, as brick do in the capital zone. At the same time, the stone deposits on the highland scarp are exceedingly valuable for the buildings and roads of the lowlands.

6. Water Conservation.

As has been stated in Chapter I, water supply is one of the greatest gifts of the highlands to the lowlands. In lands where glaciers, or heavy and well-distributed rainfalls, occur, this is given by means of perennial rivers and streams. In South Australia, where latitude and altitude are

*There are, however, considerable numbers of sheep beyond the county areas in the eastward sweep of the highlands. Density is particularly marked along the Broken Hill railway line. (Figs. 1 and 11.)

low, and rainfall is seasonal, man's assistance is required to conserve and distribute the available supply in the regions where it occurs. Thus it is that reservoirs, the most important form of water conservation by artificial means, are almost all in the highlands, where the highest rainfall, and valleys for damming, are available. From these areas, too, the supply can be distributed by gravitation.

As would be expected, the largest reservoirs are those which supply the dense population centres of the great valley. There are, however, others, which distribute water to smaller towns and agricultural areas in both highlands and lowlands. Fig. 1 shows how near the highlands are the chief population centres of the great valley. In the hills it may be noticed that the contours are very important, steep gullies being usually of less value for storage than broad, gently sloping valleys. Thus neither Millbrook nor Happy Valley are actually on the courses of the Torrens or Onkaparinga, but are nearby, and fed by tunnels from weirs in these rivers.

The principal reservoirs of the central highlands are Happy Valley, Millbrook, Hope Valley, Barossa, Warren, and Encounter Bay, in the Mount Lofty-Barossa 25 inch rainfall area (Figs. 1 and 4); Bundaleer, in the 20 inch Clare region, and Beetaloo in the 20 inch area round Mount Remarkable (Fig. 1). Happy Valley (3,200 million gallons), Millbrook (3,650 million gallons), Hope Valley, and Thornton Park supply the Adelaide plains. The last three are all fed from the Torrens. The Barossa and Warren reservoirs, each containing over 1,000 millions of gallons, supply the water of the South Para river to the Gawler and Kapunda areas. In the south the Encounter Bay reservoir supplies Hindmarsh river water to the tourist resorts of Victor Harbour and Port Elliot and to the river port of Goolwa.

In the southern Flinders highlands, Bundaleer (1,300 million gallons) and Beetaloo supply Port Pirie and the northern Yorke peninsula area, where rainfall is from 10 inch to 15 inch only. Slightly to the north the Baroota reservoir (1,450 million gallons) helps to supply Port Augusta to the north and the Port Pirie system to the south.

CHAPTER III.

THE MURRAY BASIN.

1. Physiography and Climate.

The Murray basin or low land really consists of three main economic areas, the valley of the river, the wheat lands of the mallee and so called Ninety Mile desert, and the south eastern region. All these areas were in comparatively recent times the bed of a great gulf, into which the Murray and its tributaries flowed by different mouths. Hence the whole region forms a great plain, largely composed of marine limestone. The only elevations of any consequence between the sea and the eastern sweep of the central highlands (Fig. 1) is a group of volcanic hills in the extreme south east, where very recent volcanic action has occurred. Mount Gambier, which is economically by far the most important, was an erupting volcano with three craters, which threw out an accumulation now reaching to a height of about 600 feet. At a later date there was a subsidence, and

Blue Lake, contains some 250 feet of water, and is of immense value for reservoir purposes.

The eruptive period of this volcano was of very short duration, probably only some months towards the end of a year, and the ash was only carried over some twenty-five square miles. These ash deposits, however, now form very rich soils. Other regions where volcanic action has occurred are Mounts Burr (750 feet), Graham, and Schlank.

Fig. XII. The Lower Murray, showing Irrigation Areas.
(Compiled by Charles Fenner, D.Sc., F.G.S.)

The rest of the area is of very slight elevation: the Murray, where it enters the state, is only 37 feet above the sea-level at summer level, and at Morgan only 5 feet. As is to be expected from a submarine formation, much of the soil is sandy, and the limestone in many places is on or near the surface. In spots, where the subsoil is retentive, swamps are formed (e.g., near Naracoorte). Many of these areas are being drained for agriculture. Owing to recent elevation of the coast there is a number of shallow lakes along the shore line—e.g., the Coorong, Lakes Eyre, Robe, etc. Unfortunately they are salt, and of no material value.

The Murray has reached its base level of erosion and has ceased to deepen its bed. The upper part of the river, from the border to Overland Corner, occupies a valley from 2½ to 6 miles in width, bounded by cliffs of riverborne gravels and muds. Here occur the great south (Pyap) and north west bends, which will contain large irrigation areas when the new schemes are completed. (Fig. 12.) In this region the river winds through extensive flats, with numerous backwaters and creeks. Near Overland Corner is Lake Bonney (Section 3), while just across the New South Wales border is Lake Victoria, whose waters have been allotted to South Australia under the interstate scheme. From Overland Corner to Wellington the valley contracts to a narrow gorge about a mile in width, with steep, high cliffs of marine limestone. Near Wellington the river enters shallow coastal lakes caused by a recent elevation of the shoreline. These lakes—Alexandrina, Albert, and the Coorong—are partly salt, and are unfortunately of little importance. Below them is the mouth, blocked by a sand bar, on which are dangerous breakers and only 12 feet of water. This outlet has no heavy tides to keep it scoured, and changes its position in the moving sand. Experts, from Colonel Light onwards, have viewed with doubt any suggestion of an ocean harbour in the immediate vicinity of such a mouth. It is a grave misfortune to Australia in general, and South Australia in particular, that the greatest economic river of the commonwealth should have so poor an outlet.

The climate of the Murray basin is similar in its causes and type to that of the rest of southern South Australia. The temperature of the coastal areas is extremely even; Robe, a coast town, surrounded by marginal lakes, has a range of only 13.9° F., the lowest in the State. (Fig. 2.) With such a climate this town would be one of the leading summer health resorts were reasonable communication facilities available. Inland, range rapidly increases, and reaches over 25° F. in the extreme north of the basin. Owing to absence of variations in altitude, rainfall decreases across the region with great regularity. In the extreme south an area of nearly 3,000 square miles receives a rainfall of from 25 to 30 inches, with a reliability which demonstrates how greatly the state suffers from the loss of its southern extension in long ages past. North of the 25 inch belt is a 20 inch area, bounded by the Adelaide-Melbourne railway, and embracing at least another 6,000 square miles of country. Similarly, the 15 inch line has been closely followed by the Pinnaroo railway, while the 10 inch isohyet is in the vicinity of the Murray, so that the valley of the river and the land northwards is arid.

It will be seen (Section 4) that such a distribution of rainfall has a marked effect on population and industries.

2. Coastline and Communications.

The coastline of the Murray basin represents all the difficulties of a recently elevated shoreline. The coastal region from Encounter Bay to the Victorian border has been raised in comparatively recent times, and sandhills and sandstone present a poor economic front to the sea. On the whole shoreline, Kingston, Robe, Beachport, and Port MacDonnell are the only possible harbours, and these are all exposed and far from satisfactory ports. The Murray mouth, as mentioned above, is impassible for large shipping.

Inland communications are more satisfactory, but none the less peculiar. Although steamers have navigated the Murray since 1853, the development of the river—the geographical outlet for the products of the area—has been fatally handicapped by the failure of a comprehensive scheme of locking, including the construction of a good artificial harbour on Encounter Bay. How difficult is the course of development may be judged from the report

of a Board of Engineers appointed by the states of New South Wales, Victoria, and South Australia in 1913, that "the interests of irrigation were more important than those of navigation," and that "the heavy expense of maintaining the latter is not warranted." The difficulty of utilizing river transport has been a reason for the amazing growth of railroads in the area, more particularly since the mallee lands have been opened up for wheat. Two main broad-gauge railways cross the highlands to the basin, the Adelaide-Melbourne route, which meets the river at Murray Bridge, Tailem Bend, and Goolwa (Fig. 1), and the north-eastern line, which connects to the river port of Morgan. From Tailem Bend a considerable system of broad-gauge lines has been pushed north to the river settlements, and east to the wheat lands near the 15 inch isohyet. From Wolseley, on the border, a 3 ft. 6 in. line serves the Naracoorte-Mount Gambier area, with extensions to the seaports of Kingston and Beachport. The South East has long desired railway connection with Victoria, and this has now been effected by broad gauge to Portland, although the connection to the South Australian system remains 3 ft. 6 in. Much attention has been given to the communications of the whole basin recently, particularly in regard to money voted by parliament for works at Victor Harbour. It is noteworthy that a commission has lately reported in favour of continuing the policy of hauling the products of the area over the highlands to Port Adelaide. The adoption of a true economic policy in accordance with geographic conditions is still in the balance, but there is little doubt that the future outlet of the great wheat districts and the irrigation settlements rapidly springing up in the area must be an artificial harbour on the Murray basin side of the highlands.

3. Irrigation.

The long-debated question of the respective rights of New South Wales, Victoria, and South Australia to the Murray waters was settled by the Murray Waters Act of 1915. By arrangement between these states a joint commission was appointed in conjunction with the commonwealth to carry out certain works which would ensure a regular water supply and the development of vast irrigation areas. Under the agreement, Victoria and New South Wales are constructing the great Hume reservoir on the upper Murray. New South Wales has handed Lake Victoria to South Australia as a storage area, and our government is building locks at this place and on the Murray itself, both in Victoria and in its own territory. (Fig. 12.) No. 1 Lock at Blanchetown is already completed. The total scheme will cost nearly £5,000,000, of which the Commonwealth Government will provide £1,000,000 and the state governments the remainder. The upper Murray storage will give a good flow below Albury, except during severe droughts.

In South Australia it is estimated that nearly 300,000 acres of land will be reclaimed or brought under irrigation, including 40,000 acres of dairying land, which can be gained from Lake Albert, and 75,000 from Lake Alexandrina. Many irrigation areas are already in operation above Morgan—i.e., Waikerie, Moorook, Cobdogla, Berri (including Lake Bonney), Renmark, and Ral Ral (the proposed Chaffey irrigation district). Ral-Ral, Cobdogla, and Berri will in future contain respectively 100,000, 30,000, and 8,000 acres of first-class irrigated land. South of Morgan are many small irrigation areas and reclaimed swamps—e.g., the Wellington estate, just above Lake Albert (12,000 acres). The prospects of these settlements are considerable. The reclaimed lands consist of peaty soils composed of rich river silt, and are eminently fitted for the growth of fodders and vegetables. The soils of the irrigable lands have already proved suitable for the production of numerous Mediterranean fruits,

while the long, dry summers provide excellent conditions for the fruit drying industries.

4. Population and Industries.

The distribution of population in the Murray basin offers some important examples of geographical control. As there is little manufacture or mining, there are few areas of fair concentration, except in very fertile regions, such as Mount Gambier and the Murray irrigation settlements, or on the main lines of communication. Fig. 8 shows that the course of the stream can be followed by population dots marking the settlements in its valley. From the border seawards the chief of these are Renmark, Pyap, Berri, Morgan, Murray Bridge, and Goolwa. Some centres (e.g., Renmark, Berri, etc.) owe their importance to irrigation, others are primarily centres of communication. Thus Morgan, Murray Bridge, and Goolwa are river ports, where the three main lines touch the river.*

Railways in the newly-developed wheat lands of the mallee area have similarly followed population dots. In this district the chief centres are Pinnaroo, Lameroo, and Karoonda, all of which are on or near the 15 inch isohyet. Tailem Bend is a rapidly growing rail and river junction on the edge of the Ninety Mile desert. Up to the present, however, population in these wheat lands is scattered.

The south-eastern district shows a somewhat similar distribution. The main railway has followed the better country near the Victorian border, and population is fairly concentrated from the north to the south in this region. In the well-watered Mount Gambier area a considerable agricultural and pastoral population is found, and there are fair concentrations due to similar industries at Naracoorte, Penola, Bordertown, and Millicent, and in the seaports of Kingston and Beachport. It will be noticed again that the course of the branch lines to these places have followed the population dots.

The industries of the area are strongly influenced by rainfall and geological factors. As the greater portion of the basin consists of recent marine sediments, mineral wealth is of little importance, with the exception of the lignite now being explored at Moorlands. This brown coal deposit, which is of fair quality, may, if extensive, convert the neighbouring river port of Tailem Bend into a manufacturing centre, even if insufficient to supply Adelaide with electric power. Another important industry which can be developed in the area is forestry, for which much of the country, as far north as the 20 inch isohyet, is suited. Already forests have been planted in the district—e.g., at Mount Burr (20,000 acres, the largest forest in the state)—and sawmills are successfully at work.

Agriculture and pasturing are however at present the main industries. Wheat is the principal agricultural product, but in this area other crops are of relatively greater importance than in any other region.

Figs. 8 and 9 illustrate the wheat production. By far the greatest quantity comes from the mallee lands south of the Murray, where two counties, Chandos (round Pinnaroo and Lameroo) and Alfred (south of Loxton) averaged over a million bushels per annum in 1916-20. Albert (south of Waikerie) averaged 800,000 bushels. Fair quantities of wheat are, however, grown over much of the 15 inch area.

In production per acre the yield varies closely with rainfall. The 25 inch–30 inch southern region is by far the richest (13.8 bushels per acre), but an average of 11 bushels is obtained over most of the 20 inch area. On the cleared mallee lands, between the 15 inch and 20 inch isohyets, an average yield of 6 to 9 bushels is found, but it must be remembered that

*Of these, Morgan is an excellent example of a "bend" town, i.e., a place which owes its rise to the economic importance of its position on the bend of a river.

cheap land and large holdings make profits as high as in more productive areas, where land is expensive. The main disadvantages of these mallee lands are expensive clearing, uncertain rainfall, heavy cost of haulage over the Mount Lofty ranges, and slow growth of agriculture on large areas on perpetual lease. In regard to reliability, the returns of County Grey, a 25 inch-30 inch area, during 1916-20 were 15, 15, 8.6, 15, 14 bushels per acre; those of Chandos, a 15 inch to 20 inch area, 12, 13.5, 10, 8, 4 bushels (cf. rainfall, Fig. 6e.).

Geographical control shows even more strongly in the case of cereals, such as barley and oats, which require a heavier rainfall and lower temperature than wheat. The moist Mount Gambier region, with its fertile volcanic soil, produces more barley than any part of the state except southern Yorke peninsula, and more oats than any other district. In both cases the average was about 25 bushels to the acre for 1916-20. For similar reasons the area is one of the great root crop regions of the state. Only the Adelaide district produces more potatoes and onions. Vineyards are also important in the 25 inch area round Penola.

The agricultural industries of the Murray valley represent production in a warm region, where deficient rainfall is supplemented by irrigation. The products are warm temperate fruits, such as peaches, apricots, sultanas, currants, raisins, pears, oranges, grape spirit, and olive oil. As has been indicated above, these fruits are largely produced in the upper reaches from Morgan to the border. The dried fruit trade in currants, raisins, peaches, and apricots is very important. On the lower portion of the river fair quantities of lucerne are grown for the dairying industry.

Distribution of cattle and sheep is illustrated by Figs. 10 and 11. Both are under climatic control, but rainfall and the river influence cattle to a greater extent than sheep. The former animals are most numerous in the wetter southern regions. The Mount Gambier district in 1916-20 averaged about 24,000 a year, a density of about 10 to the square mile. Of these, about one-half were dairy cows. There are comparatively few cattle in the rest of the region, except in connection with the dairying of the lower Murray.

Sheep are more evenly distributed over the region than cattle, though, like cattle, they are more numerous in the south east than elsewhere. The Mount Gambier district averaged about 450,000 (1916-20). Robe, the next county to the north, averaged over 300,000. Further north numbers decrease until in the mallee lands, and in the dry regions round the upper river, they are comparatively few. In the mallee the reason is probably that wheat farming is a more profitable industry, as the country is usually poor grazing land.

The story of the settlement of the Murray basin illustrates some interesting points of geographical control. The importance of a great river valley in the exploration of a new land was well demonstrated by the work of Captain Sturt. Although it took 27 years (1786-1813) for New South Wales settlers to cross the Great Divide behind Sydney, Sturt opened up the Murray-Darling basin and descended to the mouth of the former river in three years (1828-1830). Owing to the abundance of hunting and fishing the area was one of the densest regions of native life. Here Barker met his death at the Murray mouth in 1831, and the crew of the "Maria" were massacred in 1840. Relics of former powerful native tribes are still found along the river—e.g., at Point McLeay Mission Station on Lake Alexandrina. Like native fauna and flora, however, the aborigines are disappearing.

Until very recently the history of the Murray river valley has economically been somewhat disappointing. In spite of many efforts since the time of Governor Young (1850) the development of the river valley and

its outlet have been slow. River traffic increased from Captain Cadell's first steam voyage (1853) until 1882, when it reached a value of £1,200,000, but it has fallen off greatly in recent years, owing perhaps to over concentration on railway expansion. In the same way irrigation settlement hardly reached expectation until the recent schemes came into operation—e.g., village settlements failed, with the exception of Lyrup, while the great Chaffey irrigation colony at Renmark has only flourished of recent years.

Again, the fertile south-eastern lands have long shown an example of geographical isolation from their political capital in the great valley. Journey by rail is hindered by a break of gauge and slow transit over a long 3 ft. 6 in. line, while, to the economic disadvantage of the state, no metalled road has ever been constructed through the Coorong area. Small wonder that one of South Australia's richest regions should have long looked to Victoria for interest and trade.

CHAPTER IV.

THE WESTERN AREAS.

1. Physiography and Climate.

The west of the state is a huge tableland, which is part of the great western plateau of Australia. From the point of view of human geography, the region falls into fairly well-developed agricultural and pastoral lands on Eyre peninsula and more easterly portions of the coastal districts, and the arid and little developed Nullarbor plains and far interior. In the coastal regions the only zones over 500 feet are two areas which probably formed part of the old east-west mountain system of the state, the Gawler ranges occupying a fair stretch of country to the south of Lake Gairdner, and a small 500 ft. region in the south of Eyre peninsula. Much of the area consists of comparatively recent raised sea-floor (e.g., the Nullarbor plains), and hence limestone is frequently on or near the surface. There are, however, many outcrops of the older granite. The plateau consists of very old rocks, with an average elevation of 500–1,000 feet. (Fig. 1.) From it rise the Musgrave and Everard ranges, of considerable elevation—e.g., Mount Woodroffe in the Musgraves (5,000 ft.) and Mount Illbillee in the Everards (3,000 ft.). The Musgrave are granite masses, broken by plains and low passes. The height of these mountains is greatly obscured by enormous quantities of waste rock and sand around their bases.

Climate shows the same characteristics as in the eastern portion of the state, a steady decrease in rainfall, and a steady increase in temperature range towards the interior. As in other areas, winter rainfall is the controlling factor in human industry. Eyre peninsula is fairly well watered, receiving 15 inches to 20 inches, with a small 25 inch region round the significantly named "Green Patch." (Fig. 4.) Variability from 1900 to 1919 is illustrated by Fig. 6D, which represents County Jervois, the Cowell area. Unfortunately, in much of the peninsula poor surface conditions detract greatly from the value of the fall. To the west the Great Australian Bight sweeps the isohyets and isotherms further north. Rainfall, however, is low and penetrates but little distance inland owing to latitude, steepness of the plateau edge, and the fact that rain-bearing winds unfortunately blow from a cool sea to a warm land, while winds from inland, except in monsoonal conditions, are dry. With an annual rainfall of 10 inches and annual temperature range of 17° F., the Eucla climate approaches continental conditions. Inland, on the plateau, rainfall decreases rapidly and

temperature range is very high. Over much of the area no rainfall stations exist, but the whole region probably averages less than 7 inches per annum. Professor Taylor has pointed out that the mountains of the interior have no effect on climate, although amongst the highest in Australia. This, he considers, is due to their location in the trade wind belt. In the Andes, mountains of a height of 20,000 feet in a similar latitude, have less than 10 inches of annual rainfall on their higher slopes. Certainly in Central Australia the fact that the trades are dry water drinkers would account for aridity over very high areas.

There are no permanent rivers in the whole area, owing to the low and seasonal rainfall and the porous nature of the soil over vast districts. Creeks in the Gawler ranges, for example, even in floodtime, disappear within a few miles. In the north, the Alberga river and a few creeks occasionally discharge into the Lake Eyre basin. In these circumstances water conservation and underground supply are very important. Several small reservoirs have already been established on Eyre peninsula (e.g., Yeldulknie, 164,000,000 gallons, near Cowell), while a very large scheme to supply a large area as far as Streaky Bay is being carried out on the Tod river in the 20 inch region, near Port Lincoln. (Fig. 1.) Throughout the settled districts water is also conserved by means of artificial iron catchments leading to large tanks, which are covered in order to guard against an evaporation of over 5 feet a year. Underground supplies are obtained by means of wells and bores sunk to reach the water lying on granitic rocks below the recent sediments.

Unfortunately much of the water in this "West Coast" artesian basin is salt.

As in the eastern areas, dry conditions have produced large areas of mallee country. This stunted eucalypt vegetation possesses great water storing powers, and it is thought that the clearing of land for wheat will free considerable quantities of moisture for the soil. Inland, on the arid plateaux and ranges, vegetation consists of porcupine grass (spinifex) mulga and mallee on the flats, and salt and blue bush in the creek valleys. The Nullarbor plains take their name from the almost total absence of trees. Here salt bush and blue bush are the characteristic vegetation.

2. Coastline.

From the human point of view the coastline falls into three divisions, the gulf shoreline, the broken and fairly useful coast from Port Lincoln to Fowler's Bay, and the inhospitable and economically useless shore of the Great Bight from Fowler's Bay to Eucla.

In Spencer gulf, as in the rest of the great valley of the state, the shoreline is low and the openings shallow—e.g., Franklin Harbour, which is a possible port for small vessels, but totally dependent upon the tides. In the north is Whyalla, a fair roadstead for iron shipping.

At the end of Eyre peninsula, where the old granite ranges meet the sea, the coast is broken, and contains Port Lincoln, which is possibly the finest harbour in Australia. So great an advantage led to considering this place as a possible site for the capital, but the port was wisely condemned by Colonel Light, owing to the comparative poorness of the hinterland. In recent years the magnificent sweep of water protected by Boston Island has been adopted by the Commonwealth government as a torpedo station. With the development of wheat growing in the hinterland the place is rapidly increasing in importance as a railway outlet. In this vicinity are numerous granite islands, bearing witness to the encroachments of the sea on the softer materials. Some of these have possessed economic importance owing to guano deposits. From Port Lincoln to Fowler's Bay the granite rocks continue, and the coast is fairly broken. Unfortunately this area, like the

south-eastern coast of the state, has suffered from a recent uplift, and most of the openings are exceedingly shallow and obstructed by bars. Also, as in the south east, the uplift has created marginal lakes and swamps, which are for the most part salt. As far as Streaky Bay the poorness of the harbours is particularly pronounced—e.g., Coffin's Bay and Venus Bay. Streaky Bay, Denial Bay, Murat Bay, and Cape Thevenard are fairly satisfactory. The last is becoming important as the railway terminus port and calling place for ocean-going wheat vessels.

From the head of the Bight to Eucla are high cliffs which, as D'Entrecasteaux said, presented "an aspect so uniform that the most fruitful imagination could find nothing to say of it."

All this region is an elevated series of marine deposits, and the Bight cliffs have been formed by the wearing away of these limestones in a very uniform manner. Over the whole distance of 300 miles there is no opening, landing-place, nor anchorage. In this region even the coastal regions are desert. Here Eyre suffered terrible hardships on his overland journey from Adelaide to Albany in 1841.

Inland communications are affected by this coastline. No railways follow the shore, as the harbours of Spencer gulf and the west coast can deal with local trade. The 3 ft. 6 in. gauge system of the area therefore follows two inland routes: a southern line, which traverses the nearer hinterland and reaches the shore at Port Lincoln on the east, and Thevenard on the west, and a northern, which pushes far inland to the new wheat areas on the Gawler plateau. Two lines penetrate the more inland regions from the northern end of Spencer gulf: the private 3 ft. 6 in. railway from Whyalla to Iron Knob, and the great East-West 4 ft. 8½ in. line, which skirts the higher central plateau to the boundary of the state. The latter railway, which has been built for political and military purposes, will serve to develop pastoral industries and possibly mining in this little known area.

3. Population and Industries.

Population is not yet concentrated in this area, as is shown by Fig. 7. A large proportion of the people are found on or near the 20 inch isohyet, and the greater part of the remainder are within the 15 inch region. The north-western districts are practically uninhabited.

On Eyre peninsula and the west coast the settlements are seaports, such as Port Lincoln, Tumby Bay, and Cowell, or communication and collecting and distributing centres, such as Cummins. Much of the region was taken up at a very early date as pastoral land; large areas were developed as "back country" of coastal stations. The land was at first used for winter pasturing, sheep being run on open plains in the mallee. Unfortunately, in many districts attempts at closer settlement were foiled by lack of water, native dogs, and rabbits, and it was not until the spread of wheat farming that the possibilities of the region were recognized. This is fully borne out by Figs. 8, 9, 10 and 11. The whole of the coastal districts averaged only some 13,000 cattle (1916-20), and of these by far the greater number were in or near the 20 inch area round Port Lincoln, or the 15 inch region behind Cowell.

Sheep, too, were very few; the average number in the coastal areas was about 500,000. Here again more than half were in the south within the 15 inch isohyet. While winter rains are satisfactory for these animals, the long, dry summers render natural feed scarce, and the problem of water supply difficult. As the latter is developed by conservation it is probable that small flocks will increase in importance.

At present agriculture is by far the most valuable industry of the area. Wheat is the stable product, though barley and oats are produced in the Port Lincoln district and oats round Cowell. The average wheat output

in 1916-20 was some three million bushels per annum, the greater part of which was grown in the coastal districts south of the 15 inch isohyet. Here Jervois, the county around Cowell, produced over 800,000 bushels per annum (1916-20), and Flinders, the Port Lincoln county, and two counties on its west (i.e., as far as Denial Bay), over 400,000 bushels a year each. Figs. 8 and 9 show that the total output, average yield per acre and rainfall do not altogether correspond. Owing to better soil and surface conditions the newly developed inland plateau areas actually producing a better average than the moister coastal regions. Rainfall, however, is perhaps less reliable than in such districts as the Adelaide plains, and capital is therefore essential to tide over poor seasons. It is, on the other hand, rather early to judge, as the records for these new districts cover relatively few years.

Wheat growing will, however, probably increase greatly, as climate is very favourable, rainfall in particular being fairly consistent, with 75 per cent. of the fall between April and October. Land, too, is cheaper than in the more settled parts. There are few other industries in the coastal region. Mining is disappointing in the old southern rocks, and there is only one forest, at Wandilla, in the 25 inch area. Forestry could probably be greatly extended.

Farther north, the Gawler ranges, the Lake Gairdner region, and the great plateau present examples of desert industries. In the north-eastern portion of the Gawlers, however, are iron deposits of excellent value, both to South Australia and the Commonwealth. Here at Iron Knob and Iron Monarch the Broken Hill Proprietary company is quarrying a practically inexhaustible quantity of exceptionally pure ore, of which over £5,000,000 worth has already been obtained. The mineral is shipped from Whyalla to Newcastle, New South Wales, for smelting, as it is cheaper to carry iron to coal than vice versa. There are already 400 people at Iron Knob and 1,200 at Whyalla. A reservoir is being constructed at Tassie creek. The only other important industry at present developed in this vast region is pasturing. Figs. 10 and 11 show that there are fair numbers of sheep and cattle on the eastern margin of the plateau. The East-West railway will probably greatly help to further this industry. The whole of the north west of the areas is undeveloped and largely unexplored. In Stuart range a valuable opal field is being opened up. Salt and gypsum will also be important mineral products at a future date. Lake Macdonnell, near Port Le Hunte, on Fowler's Bay, contains over two and a half million tons of salt, and Lake Hart, on the East-West railway, some 12,000,000 tons. To the north and east of Lake Macdonnell gypsum deposits of nearly 70 million tons are being worked.

CHAPTER V.

THE CENTRAL BASINS.

1. Physiography and Climate.

This huge inland area of the state is of great interest, both from the geographical and human points of view, as it is one of the most important areas of inland drainage of the world, and is of fair economic value. The region, which in South Australia covers an extent of about 100,000 square miles, consists largely of rocky flat-topped tablelands of what is called desert sandstone, stony deserts or gibbers formed by the weathering of this

material, and sand ridges, which usually form at right angles, or, as it is called, "normal" to the prevailing winds. In the southern portion of the basin lies a great horseshoe of shallow lakes, separated from one another by low divides, which in no case reach 300 feet. Of these the most important are Lake Torrens at the northern end of the Great Valley, Lakes Eyre, Gregory, Blanche, Callabonna, and Frome. (Fig. 13.) Of these, Lake Eyre, the largest, has an area of some 3,700 square miles, and lies about 40 feet below sea-level. Into these lakes in time of rainfall flow a large number of rivers, none of which are permanent, though the flood waters of the Barcoo and Diamantina flow for some months. It is considered by Professor Taylor that the whole of this drainage originally found its way to the gulfs, but was pushed to the eastward by the uplift of the central highlands, and cut off from the sea by the depression of the central regions. It is often said that this region should be flooded by a canal to the head of Spencer gulf, but, as Professor Taylor has shown, the water area would only be increased to 5,000 square miles. If climate could be rendered more moist in this way the only result would probably be to give Australia another tropical area such as those which she has shown such conspicuous inability to develop.

In this area climatic conditions, more particularly rainfall, are the controlling factor in human life and industry. Gregory describes the greater portion of the region as a desert, "using that term in its generally accepted modern meaning of a country with such an arid climate and such a scanty water supply that agriculture is impracticable and occupation is found possible only for a sparse population of pastoralists." Yet this same territory in good seasons has been described by other observers as "a land of lakes and meadows." In most seasons, however, Gregory is right; rainfall in very low, in no case exceeding 10 inches, and is also most uncertain—e.g., at Kanowna, where the average fall is 4.4 inches, over 6 inches fell in five days in November, 1911. In regard to the seasonal fall there are three divisions: the south has a winter maximum, the north east a summer maximum, and around Lake Eyre is an area of uniform aridity (Figs. 4 and 5). In so continental a region range of temperature is great (Fig. 2) and the summer heat considerable. Hunt, however, speaking of the Australian tropical zones, says: "Inland life is generally enjoyable, although the thermometer may, in extreme cases, reach as high as 120° F. in the shade, the dryness of the air and consequent rapid cooling of the skin by evaporation preventing serious discomfort when protected from the direct rays of the sun. Nocturnal radiation, too, as contrasted with that of the coastal districts, is very active, so that the nights are invariably cool, and an absence of monotony of temperature tends to a bracing of the system and to good sleep at night."

With so high a temperature and low a rainfall the flora of the region is composed of drought resisting plants, which are capable of withstanding great heat and aridity, and at the some time can germinate with sufficient rapidity to avoid the severe winter frosts. This desert flora differs in quantity according to rainfall, but not in type. The southern regions of the Lake Eyre basin, with a 9 inch annual fall, are true winter grass lands or steppes. Further north, on the tablelands or stony plains, is salt bush, and, after rains, wiry "panic" grasses. In the river valleys, with loamy and sandy ground, are strings of eucalypts, rushes, acacia (mulga), and buck bush; the last two are edible for stock. On the whole, the west is probably more fertile than the east, which contains Sturt's Stony and Gregory's Tirara deserts, but the artesian water supply of the east more than compensates for any difference.

2. Artesian Water.

The artesian water supplies are so important and characteristic that the whole of the Lake Eyre basin, both in South Australia and beyond, is frequently called the "Great Artesian Basin." (Fig. 13.) The vast quantities of underground water probably originate partly on the western slopes of the Queensland plateau and partly in local districts.* On the western slopes of the "Great Divide" the water penetrates limestones, sandstones, and soft strata, and, soaking down to harder rock, finds its way under the surface to the Lake Eyre region or the Gulf of Carpentaria. On the South Australian-Queensland border the bedrock is nearly 5,000 feet down, while to the west of Lake Eyre it is so near the ground that the water is forced up in a series of "mound springs." Thus the Goyder's Lagoon bore, on the border, is 4,800 feet in depth, that at Coward in the western side of the basin 308 feet. From great depths this water issues at considerable temperature; that at Goyder's Lagoon has a temperature of 208° F. In some cases the flow from these bores is enormous, reaching 800,000 gallons a day at Kopperamanna, and 100,000 gallons at Coward. Unfortunately the general opinion of observers throughout the area is that supplies are being gradually depleted.

The water is brackish, but is fit for stock, and hence is of the greatest value for stations and on the stock routes, making large areas "safe" country. It has been tried for agriculture with variable results; grass and trees are grown with its aid in places (e.g., at Oodnadatta). Salinity is probably lessened by the Gulf of Carpentaria outlet and the overflow in the western margin. Here the mound springs, which number thousands, are probably caused by a barrier of impervious rock, which forces the water to the surface, where mineral matter in solution causes a mound. These springs run in a line from Hergott northwards. Settlement, and at later date, the railway, have largely followed these outlets.

3. Communications.

In this wide expanse, where there are no waterways, railways are an essential means of communication. Lines in such regions have several objects—the development of the country, connection of fertile areas one with the other, and military strategy. At present the Lake Eyre basin is penetrated by one narrow gauge railway, now controlled by the Commonwealth government. This line was pushed as far as Oodnadatta by the South Australian government, with the hope of making political and commercial connection with the Northern Territory when the state controlled that area. The Commonwealth, under the Federal Agreement, is pledged to finish the line, a most necessary object for strategic and commercial regions. As can be seen from Fig. 1, the railway follows the 10 inch rainfall belt as far north as Beltana. About 80 miles farther on Hergott, or Marree, is reached, and the mound springs are followed to Oodnadatta. Up to the present the line shows a working loss. It has, however, opened much country, and is the only great commercial highway in the area, except for two stock routes to Queensland, which are dependent upon artesian water—the Diamantina track to Birdsville, and the Strzelecki route. (Figs. 1 and 13.)

3. Population and Industries.

The population of this central basin is typical of an arid pastoral area. It consists of a few settlements along the railway and Birdsville track, and

*The Interstate Conference on Artesian Water (1912) reported: "We have no hesitation in stating that, in our opinion, the ascertained facts indicate that this water is almost wholly, if not entirely, derived from rainfall; and that it percolates the porous beds under the influence of hydraulic conditions."

Fig. XIII. South Australia.– Artesian Basins and Stock Routes, based on Government publications.

widely scattered groups in the stations of the artesian area and southern steppes (Fig. 7). As recent sediments of the basin exclude chances of mining, and the wheat belt ends even before the northerly limits of the 10 inch isohyet, population is entirely dependent upon pasturing. Figs. 10 and 11 illustrates the distribution of cattle and sheep in the area. The whole region contains no less than a quarter of the state's cattle and nearly one-fifth of its sheep, though the average per square mile is small. For statistical purposes the district is broken up into three divisions, the north-east, north, and north-west. As will be seen from the diagrams, the first of these is most important for sheep, the last for cattle, which are reared for meat and require less protection against wild dogs than do sheep. The north-east averaged about 32,000 cattle and 600,000 sheep (1916-20), the north-west about 40,000 cattle and 170,000 sheep, though many of these are of course in the plateau area. (Figs. 1 and 11.) The north had about 10,000 cattle and 115,000 sheep. Though these figures appear large, it must

be remembered that the territory is immense, and that the distribution per square mile is lower than in most of the county districts. As a means of transport camels are important. There are over 2,000 in the area.

The story of the exploration and settlement of the region is one of heroic struggles against climatic and physical difficulties of great magnitude. Eyre (1840), Sturt (1845), and Babbage (1856) all penetrated the region, while John McDouall Stuart, after frequent failures, traversed it in the first successful attempt to cross the continent from south to north (1862). Rapid pastoral development followed these successes, and in 1870-72 the population of South Australia—then only 200,000 persons—undertook to establish the overland portion of the Adelaide-Port Darwin-Europe telegraph, a work involving the construction of 2,000 miles of line in a semi-arid region. South Australia was also responsible for the construction of the Oodnadatta railway in 1891, as a cost of over £2,000,000; the interest on this sum and the working loss of the line are now being paid by the Federal Government. In no region, in fact, has the energy and stamina of South Australians been more clearly demonstrated than in the successful opening up of the dry northern areas of the state.

CHAPTER VI.

PRODUCTION AND COMMERCE.

1. General Production: Trade and Commerce.

Much of the general information in regard to South Australians and their industries has been given in the regional chapter above, but certain points remain for comment. The greater portion of the population of the state is engaged in the production or exchange of various types of wealth, a process closely controlled by those varying geographical factors already outlined. How these different types of industry affect the distribution of the people has also been related.

For the period 1916-20 the total production of wealth in South Australia averaged rather more than £27,500,000 per annum, a sum of about £60 a year per head of population. The main items of this output were, approximately: agricultural products, £12,300,000; manufactures, £6,400,000; pastoral products, £4,800,000; dairying, £1,400,000; mining, £1,200,000; miscellaneous, £800,000; poultry, £600,000.

Of agricultural products, wheat is of overwhelming importance. For 1916-20 the average annual yield, which includes the record harvest of 1916-1917, was rather more than 29,000,000 bushels (11.8 bushels per acre). The annual value of this crop has averaged about £7,760,000. Such a yield places South Australia a close third to Victoria and New South Wales in the wheat-growing states of the Commonwealth. In the last 10 years the wheat acreage has altered but slightly (2,104,717 acres in 1910; 1,926,915 acres in 1920); in 1916-17, however, a much greater area (2,778,357 acres) was planted. The following table, which shows the average yield for ten decades, 1860-1919, is important:

1860-9 (average winter rainfall, 15 in.)—average yield, 10.5 bushels; total p.a., 4,000,000 bushels.

1870-9 (average winter rainfall, 14.4 in.)—average yield, 9 bushels; total p.a., 8,500,000 bushels.

1880-9 (average winter rainfall, 12.2 in.)—average yield, 5.9 bushels; total p.a., 10,800,000 bushels.

1890–9 (average winter rainfall, 11.8 in.)—average yield, 4.6 bushels; total p.a., 7,600,000 bushels.

1900–9 (average winter rainfall, 12.15 in.)—average yield, 8.6 bushels; total p.a., 15,200,000 bushels.

1910–19 (average winter rainfall, 11.2 in.)—average yield, 10 bushels; total p.a., 23,300,000 bushels.

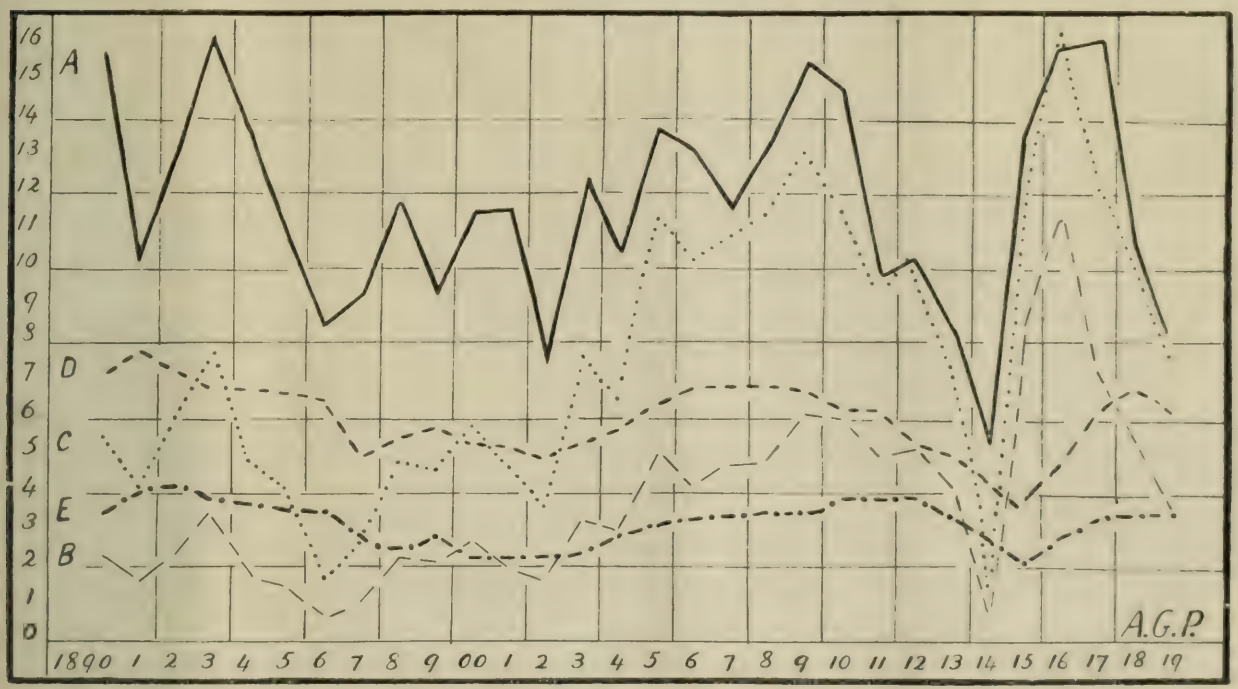


Fig. XIV. Graphs to illustrate Rainfall, Wheat Production, Sheep and Cattle. 1890 to 1919-20. A. Winter rainfall (April-October) for wheat growing areas, in inches. B. Annual wheat yield, in 4 millions of bushels. C. Average wheat yield, in bushels per acre. D. Sheep, in millions. E. Cattle, in hundreds of thousands.

The rainfall in this table is the average fall from April to October in the counties. It shows that the fall in the southern part of the state is fairly reliable; the variation, as a matter of fact, is from 15 per cent. to 20 per cent. per annum. The most noteworthy fact illustrated, however, is that the enormous increase of the last twenty years is due, not only to greater areas planted, but to far better methods of cultivation and types of grain. Fig. 14 illustrates total production and yield per acre over the last thirty years. It will be seen how closely both correspond to the April-October county rainfall. The effect of a fall of over 16 inches in 1916, resulting in a record harvest of 45,750,000 bushels, will be noticed. On the other side is the winter rainfall of 1914 (5.3 inches) resulting in a harvest of 3,500,000 bushels.

Great as is the recent increase in production, South Australia has by no means reached its maximum. Professor Taylor states that there are some 47,000 square miles of country, or 30 million acres, within the 10 inch rainfall area, and that, allowing that half (15 million acres) is suitable for wheat, and produces an average of 10 bushels per acre, a total of 147,000,000 bushels can be aimed at. Even allowing half the land for fallow, 70,000,000 bushels can be reached. In 1920 all landholders forwarded estimates of the average of their land suitable for wheat cultivation. The area given was about 13½ million acres, which does not allow for unoccupied lands. As the average yield for the last 20 years has been 9½ bushels per acre, this closely agrees with Professor Taylor's estimate.*

*Dr. Fenner comments as follows on the growth of agriculture, more particularly of the wheat industry: "To-day, owing to the application of a knowledge of chemical manures, of specially selected drought resisting wheats, of irrigation and dry farming,

Compared with the wheat yield, other agricultural products seem small. About 600,000 tons of hay were produced annually (1916-20), valued approximately at £2,100,000 a year. Vineyard produce, wine, table grapes, currants and raisins were worth £800,000 per annum, of which wine (4,700,000 gallons) was valued at more than £500,000. Wine-making is increasing enormously in value to the state. In 1921 7,893,000 gallons worth £993,000, were made. This production was 55 per cent. more than that of 1920, and was easily a record. Barley (2 million bushels, £430,000) and oats (1,600,000 bushels, £250,000) are crops which are also growing greatly in value. In the last decade their average has respectively increased 277 per cent. and 125 per cent., and this largely accounts for the land which has recently gone out of wheat cultivation. Fruits, both fresh and dried, are important crops increasing rapidly in value. For 1916-20 the total annual fruit production averaged £430,000, of which dried fruits were about a sixth. Fresh apples were by far the most valuable crop. Other agricultural products of some importance were root crops (£150,000) and market garden produce (£114,000).

In the pasturing industry the chief animals are sheep, cattle, and pigs. The last are generally included under dairying. There are approximately 6,000,000 sheep, 350,000 cattle, and 60,000 pigs. Horses number some 265,000. Fig. 14 illustrates numerical fluctuations in cattle and sheep between 1891 and 1920. It will be seen that numbers follow annual rainfall, though less closely and with a greater lag than the wheat yield follows the winter fall. Stock were greatest about 1891-2, following good rainfall years. Bad seasons from 1896 to 1902 were succeeded again by a period of prosperity, when the flocks and herds reached 7,500,000. The great drought of 1913-14-15 reduced numbers to little more than four millions, but with good seasons recently seven millions has been again exceeded.

The main pastoral product of the state is wool, which increased considerably, both in quantity and value, from 1916 to 1920, averaging about £2,600,000 per annum for the period. Other important products are meat and skins. From 1916 to 1920 an average of a million sheep, 75,000 cattle, and 100,000 pigs were slaughtered annually. Of the dairying industry, the products are butter (average, 9¼ million lbs.), bacon and ham (5 million lbs.), and cheese (2¼ million lbs.). These industries are fairly steady in output, but value has increased greatly in recent years, owing to the rise in prices.

As has been stated previously, copper is the staple mining product of the state; production for the last five years has averaged 115,000 cwts., valued at about £640,000 a year. The total output to 1920 has been eight million cwts., valued at nearly £26,000,000. The production of ironstone from the western plateau is however rapidly increasing; the average for the period is about 300,000 tons per annum, valued at some £325,000 a year. In 1920 this production reached 413,000 tons, valued at £478,000. The only other exceedingly important mineral product is salt. For 1916-20 the annual output was 68,000 tons, valued at £126,000. In 1920 over 70,000 tons were produced.

In 1920, gypsum for plaster of paris, cement, etc. (£31,000), opals (£24,000), phosphate rock for fertilizers (£12,000), limestone (£9,000),

and by the adoption of improved farming methods generally, thousands of square miles are cultivated and hundreds of miles of railways built between the 10 inch and 14 inch lines, in the West Coast and Pinnaroo areas. . . . Already we have pushed our frontiers from the 14 inch to the 10 inch line, and with the spread of such knowledge as will cause the further application of scientific principles to agriculture, so may we in future advance still further outwards. It is possible to suggest several ways in which this may take place, as for instance: (a) a better knowledge, use, and control of our artesian areas; (b) development of irrigation; (c) further application of dry farming methods; (d) breeding and selection of drought-resisting crops."

barytes, a very heavy mineral mined at Noarlunga and used in paints (£7,000), gold (£7,000), and manganese ore (£4,000) were the other principal mineral products.

Of miscellaneous industries, fisheries and timber may be noticed. For the period 1916-20 the value of fish taken in the continental shelf around the shores and in the Murray averaged nearly £230,000 per annum in value. With better means of transport these supplies could probably be greatly augmented. Over the same period over four million super. feet of timber were sawn in the forests annually. Most of this was obtained in the state forests, which show a slight but rapidly decreasing annual loss. Another important minor industry is bee-keeping, which is carried on in conjunction with other pursuits; for 1916-20 about a million pounds of honey were produced annually.

These various types of primary production give an annual value of nearly £21,000,000 out of a total production of £27,500,000 (1916-20). Manufactures are at present of distinctly secondary value, with some £6,500,000 a year. It is interesting to note in this connection that in 1920 51,452 persons, permanently employed on the land, produced wealth to the value of over £22,000,000, or more than £425 per head. In the same year 29,442 people employed in manufacture added less than £7,500,000 to the value of raw materials used, a total of about £250 per head. As has been indicated above, many of the chief factories are engaged in the manufacture of locally produced raw materials. In 1920 there were 1,093 factories in the state, employing over 51,000 persons. Of these establishments nearly 80 per cent. used mechanical power, steam, gas, and electricity being the principal powers available. It may be noticed that the use of the last-named is increasing enormously. The following list gives the number of persons employed and the value added to the raw materials in the principal manufacturing industries during 1920. The figures given are approximate.

Metal works and machinery ..	7,267	persons; value produced,	£1,700,000
Clothing, textiles, etc.	5,342	persons, value produced,	£750,000
Foods and drinks	4,159	persons; value produced,	£1,500,000
Vehicles, saddlery, etc..	2,226	persons; value produced,	£430,000
Printing and paper	2,035	persons; value produced,	£470,000
Stone, clay, and glass	1,690	persons; value produced,	£450,000
Working in wood	1,456	persons; value produced,	£380,000
Heat, light, and energy	1,075	persons; value produced,	£530,000
Furniture, bedding, etc.	1,049	persons; value produced,	£200,000
Drugs and chemicals	818	persons; value produced,	£290,000

As has been stated in Chapter I, the imposition of a heavy Federal tariff on imported manufactured goods has led to a great growth of manufactures in the state. Over the last decade the number of factories has increased 7 per cent., and the product 67 per cent. As the number of persons employed has only increased 9 per cent., it is probable that the great improvement in the value of production is due to the rise in prices and increased use of mechanical power.

Mention of power strikes the keynote of the future of South Australia as a manufacturing area. At present, throughout the world, the chief sources of industrial energy are black coal, mineral oils, and hydro-electric energy. Owing to climatic and other factors it is unlikely that the state will be able to utilize the last-named either from rivers or tides, while the existence of black coal or mineral oils is regarded as improbable by leading geological experts, though considerable sums are being spent in exploration. At the same time, the state undoubtedly possesses valuable fields of lignite, or brown coal, at such places as Moorlands, near Tailem Bend, Leigh's

Creek, Hope Valley, and Clinton, on Yorke peninsula. The last is a recent and most hopeful discovery. This lignite can probably be used to generate electricity, as in Germany, and in the Morwell scheme being undertaken to supply Melbourne. Another potential source of energy is industrial alcohol. It has been estimated that the straw grown annually within 100 miles of Adelaide would probably produce alcohol of equal power value to the whole present petrol and kerosene imports of Australia. Another possibility is direct sun power, concentrated by means of glass, for the production of low-pressure steam. Such an apparatus as the Schumann, which is being used successfully for irrigation in Egypt, would be invaluable in the Murray basin, where its efficiency would be greatest at the time of greatest need.

2. Trade and Commerce.

The trade and commerce of South Australia, like the producing industries, illustrate the comparative importance of agriculture and pasturing as compared with manufactures. In the great majority of cases the state is dependent upon other areas as a market for raw materials, and as a source from which to draw manufactured goods. South Australia, however, possesses what is known as a favourable balance of trade; that is to say, the primary products exported exceed in value the manufactured goods imported in exchange.

Unfortunately, it is most difficult to estimate correctly the value of this interchange of commodities, for since 1910 no record has been available of interstate transactions, which are of considerable magnitude, and deductions can in general be based only upon goods directly imported to and exported from South Australian ports. In the year 1909, when records ceased, the South Australian total trade was £24,000,000, of which some £14,000,000 represented oversea and £10,000,000 interstate trade. Of this foreign trade exports were nearly £9,000,000 and imports £5,000,000. In the period 1916-20 total foreign trade averaged rather more than £16,000,000 per annum, of which exports were rather more than £10,000,000 and imports slightly less than £6,000,000. In 1920 the value of direct trade reached the huge figure of £28,000,000; exports, £20,500,000; imports, £7,500,000. The enormous total reached by exports was partly due to the accumulation of stocks in the country during the shipping shortage of previous years.

A detailed consideration of the principal items of export and import fully demonstrate the strength of our production of raw materials in comparison with manufactures. Exports, for example, are for the most part primary products. Wheat and breadstuffs are easily the most important item, and are followed by animal products, such as wool, meats, hides, and tallow, and vegetable products such as jam, wine, and tanning bark. Mineral exports, copper, iron, lead and zinc are also very important. The average wheat export (1916-20) was 16,000,000 bushels, valued at about £4,200,000 per annum. For the same period the flour export was some 64,000 tons, valued at £800,000 per annum. The wool export has averaged some 41,000,000 lbs., worth about £2,600,000 a year.

In 1920 the main exports were approximately:

Agricultural produce: Wheat, 42,000,000 bushels (£11,000,000); flour, 85,000 tons (£1,500,000); barley, 577,000 bushels (£196,000); fruits, chiefly currants and raisins, £157,000; wines, £65,000; jams, £45,000.

Pastoral produce: Wool, 70,000,000 lbs., £4,470,000; frozen meats, mutton £279,000, lamb £89,000, beef £11,000; tinned meats, £84,000; butter, 2,400,000 lbs., £182,000; skins, sheep and rabbit, £512,000; tallow, £137,000; leather, £77,000; horses and sheep, £20,000.

Minerals: Copper, £488,000; lead, £218,000; zinc, £144,000; salt, £24,000; silver bullion, £200,000.

Miscellaneous: Jewellery, £58,000; manures, superphosphate, rock phosphate, ammonium sulphate, £36,000.

It will be seen that the greater portions of these commodities are raw materials.

On the other hand, the chief imports are manufactured goods, except for tropical and cold temperate primary products, which cannot be grown in the Mediterranean climate of the state. This is shown by the following imports for 1920:

Metal manufactures, iron, steel, machinery and machines, wire, vehicles, tools, etc., £2,000,000; textiles, £1,346,000; apparel, £310,000; sugar, £906,000; bags and sacks for the cereal crops and wool packs, £366,000; drugs and chemicals, carbide, cream of tartar, fertilizers, sulphur, etc., £346,000; oils, £396,000; timber, £247,000; tea, £214,000; paper, £170,000; rubber and rubber manufactures, £130,000; stationery and books, £88,000; fish, £66,000. Cocoa, coffee, glass, gums and resins, jewellery, leather manufactures, spirits, pipes and tobacco, yarns, fibres, and many other goods in smaller values.

A consideration of the direction taken by South Australia materials of commerce affords a good example of the interdependence of various climatic or natural zones. This relation is due not only to geographic but to historic reasons, which have given the state a close economic connection with the Motherland. Broadly speaking, the chief South Australian foreign trade is with (a) the British Isles, which possess an industrial population so enormous that the importation of food supplies and of raw materials for the manufactures of great coal and iron areas is essential; (b) with other European countries, France, Italy, Belgium, etc., which are both primary producing and manufacturing lands, but require foodstuffs to supplement home supplies, and raw materials for their factories; (c) with the great North American lands (United States and Canada), which are both primary producing and manufacturing areas. These countries supply us with cold temperate products (e.g., timber) and manufactured goods. They sometimes require our commodities (e.g., wool) to supplement their own output. Generally, however, balance of trade is unfavourable. (d) With tropical lands (India, Java, etc.), which under climatic influence can produce such commodities as sugar, tea, rice, and jute. Such lands frequently take Mediterranean foodstuffs in exchange. (e) With certain primary producing lands of very similar climate and type to our own, whose own industries, however, are not sufficiently advanced to allow them to dispense with our products (e.g., South Africa).

The British Isles are the great recipient of our exports, and the main source of imports. It is well for South Australians to remember that to the heart of the Empire they owe, not only their safety and strength, but their satisfactory commercial position. In 1919-20 57 per cent. of the state's total trade was with the United Kingdom, which absorbed 63 per cent. of exports and supplied 43 per cent. of imports. In exchange the state sent, in 1920, wheat (£7,300,000), wool (£3,000,000), flour (£114,000), practically the whole export of meat and butter, and most of the export of metals, skins, wines, fruits, jams, and jewellery. The imports, for the greater part manufactured goods, did not reach one-half of the value of Britain's wheat purchase alone. The main imports were textiles (over £1,000,000), manufactures of metal, machinery, vehicles, etc.; (£750,000), spirits, glass, china, books, jewellery, fish, electrical apparatus, manufactured rubber and leather goods, and various kinds of metal (e.g., iron).

To other European countries the state in 1920 exported wheat for food and wool for textile industries. Trade with France ranked second to that

with the United Kingdom, and that country took £2,600,000 worth of wheat and £424,000 wool. Italy purchased £379,000 of wheat and £432,000 of wool, and Belgium £396,000 of wool. In return South Australia imports considerable quantities of textiles (e.g., French silk), olive oil (France), glass and china (Belgium), cream of tartar and tartaric acid (Italy). Here in all cases exports greatly exceed imports. Norway and Sweden also take large quantities of primary products—e.g., Norway took £250,000 of wheat in 1920. From their forests South Australia obtains paper, timber, and matches, while the Norwegian water-power produces the chief foreign import of calcium carbide (£14,000). Sweden is a great dairying land, and from it is obtained most of the dairying machinery. From the Norwegian cold water fisheries come considerable quantities of tinned fish.

Commerce with the United States in 1920 ranked third to the exchange with the United Kingdom and France. The total trade in that year was £1,840,000, a rather greater sum than the average for the years 1916-20. Owing to the fact that the United States is both one of the greatest primary producing and manufacturing countries imports greatly exceeded exports, £1,560,000 as compared with £280,000. As the United States is the greatest wheat producing area in the world, no South Australian wheat was exported there, but wool (£135,000), ores (£64,000), and rabbit skins were purchased. From the United States were imported metals, metal manufactures, machinery, etc. (£800,000), timber (£150,000), petroleum, kerosene, and lubricating oils (£137,000), textiles and apparel (£113,000), paper, tobacco, rubber, and leather manufactures. The United States has such a varied climate and production that South Australia purchases a wide range of commodities. Canada, in the same way, requires practically none of the state's products, but has vast primary producing and manufacturing industries, which supply various South Australian needs. In 1920 imports were of a value of £277,000. From the Canadian softwood forests were received timber and paper, from the water-power calcium carbide, from the industrial areas many manufactured products—e.g., agricultural machinery. An interesting import was that of £72,000 worth of motor cars, largely of United States design, which entered under British preferential tariff. Canada has some of the most important fisheries in the world (cod on the east and salmon on the west), and from them South Australia obtains considerable quantities of fish.

The tropical lands take many of the state's warm temperate products, and supply commodities that cannot be produced under a Mediterranean climate. Monsoonal lands, such as India, Ceylon, China, and Japan, are both primary producing and manufacturing areas; modern machinery is now rapidly replacing the old handicraft industries. In 1920 the value of trade with these countries and the East Indies was considerable. Trade with Java was £1,160,000; India and Ceylon, £865,000; Japan, £600,000; Sumatra, £187,000, and China, £130,000. Most of these countries take our primary products, particularly wheat and flour, minerals and wool. Thus in 1920 Java took £162,000 of wheat and flour; India and Ceylon, £150,000 of copper and £24,000 of silver; Japan, £484,000 of wheat, £37,000 of zinc; China, copper and £90,000 silver bullion. In return, South Australia received from the East Indies sugar (Java, £900,000), petroleum and kerosene (Sumatra £178,000, Borneo £33,000), spices, sago, tapioca, coffee, tea, and tobacco. From India and Ceylon enormous quantities of bags and wool sacks, made from jute and hessian (£360,000), and tea (£130,000). From Japan apparel and textiles, including silk, sulphur, china and glass, matches, and metal manufactures. From China, textiles (including silk),

tea, and rice. There is also minor trade with other tropical areas—e.g., dates from Mesopotamia and coffee from Asia Minor.

Considerable trade is also carried on with countries not unlike Australia in climate—e.g., South Africa, whose trade was worth over £550,000 per annum. To South Africa were sent £450,000 worth of flour and wheat, and sheep for breeding purposes. The trade is almost entirely an export one. Commerce to the value of £140,000 is also carried on with New Zealand—e.g., salt for the meat industry and phosphates are exported, and New Zealand white pine imported.

APPENDIX.

THE CLIMOGRAPH.

Climatic differences in South Australia are probably most vividly illustrated by the device known as the Climograph, made popular by Professor Taylor in Australia and Huntingdon in America.* The methods adopted by these two geographers differ, and will be found discussed

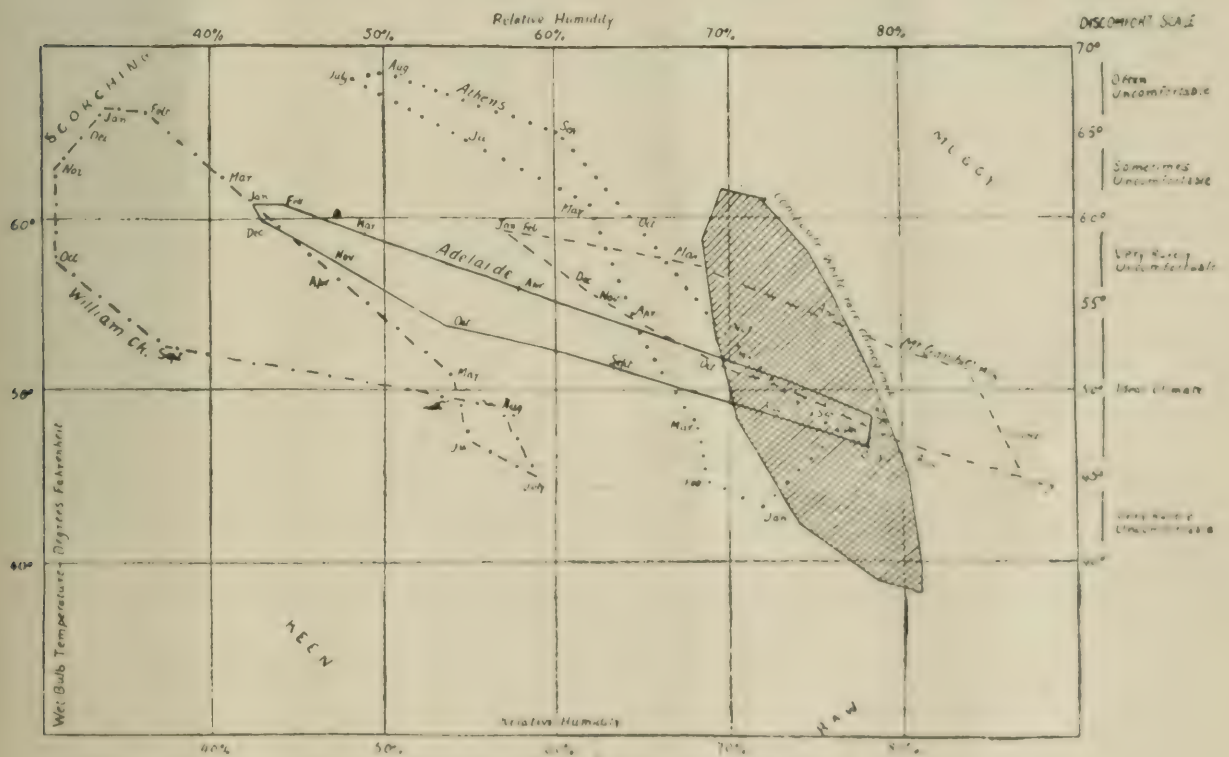


Fig. XV. Climographs for South Australia (Athens added for comparison).
(From Professor Griffith Taylor: The Commonwealth Meteorological Bulletin, No. 14.)

in the Commonwealth Meteorological Bulletin, No. 14, and in Huntingdon's "World-power and Evolution." Professor Taylor's method, illustrated by Fig. 15, is undoubtedly the more striking. By it the climate of any place is pictured by plotting the wet bulb temperatures vertically, and the relative humidities horizontally on a scale for every month of the year. The result is a twelve-sided polygon differing so greatly in shape for the various great species of climate that any type can be recognized at a glance. In order to simplify matters further, the high temperature areas of the diagram are marked "muggy" and "scorching."

*The term "climograph" was introduced by Professor Taylor. Very interesting discussions on the climograph method can be read in the Geographical Review, New York, November, 1917, and January, 1918.

according to the percentage of moisture present in the air, and the low temperatures similarly "keen" or "raw." A tentative scale of discomfort is also added.

Fig. 15 illustrates the variations of South Australian climate. The shaded figure is a composite climograph for twelve of the greatest white cities of the world, and can be regarded as the ideal climate for such races as the Anglo-Saxon.

It will be seen that Mount Gambier falls within it during March, August, and September, while April, May, June, and July are wetter and cooler than the average. Adelaide, on the other hand, is within the average for May, June, and July, while during the summer the climate approaches scorching. The distinct Mediterranean cigar-shape of these climographs may be noted. Athens is added for comparison. William Creek is a typical climograph of arid conditions. The long hot summer is clearly shown, and also the fact that the climograph begins to take a crescent shape, denoting a summer as well as a winter rainfall. Here, as a matter of fact, March, .73 in., is the wettest month. At the same time even this climate is a healthy one for the white races. Only when the polygon is found in the "muggy" corner, as for Darwin and Papua, or far below in the "raw" or "keen" zones, as Ross Island in the Antarctic, does the climograph illustrate impossibility for permanent white settlement. No region of South Australia can be possibly included in such areas.

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